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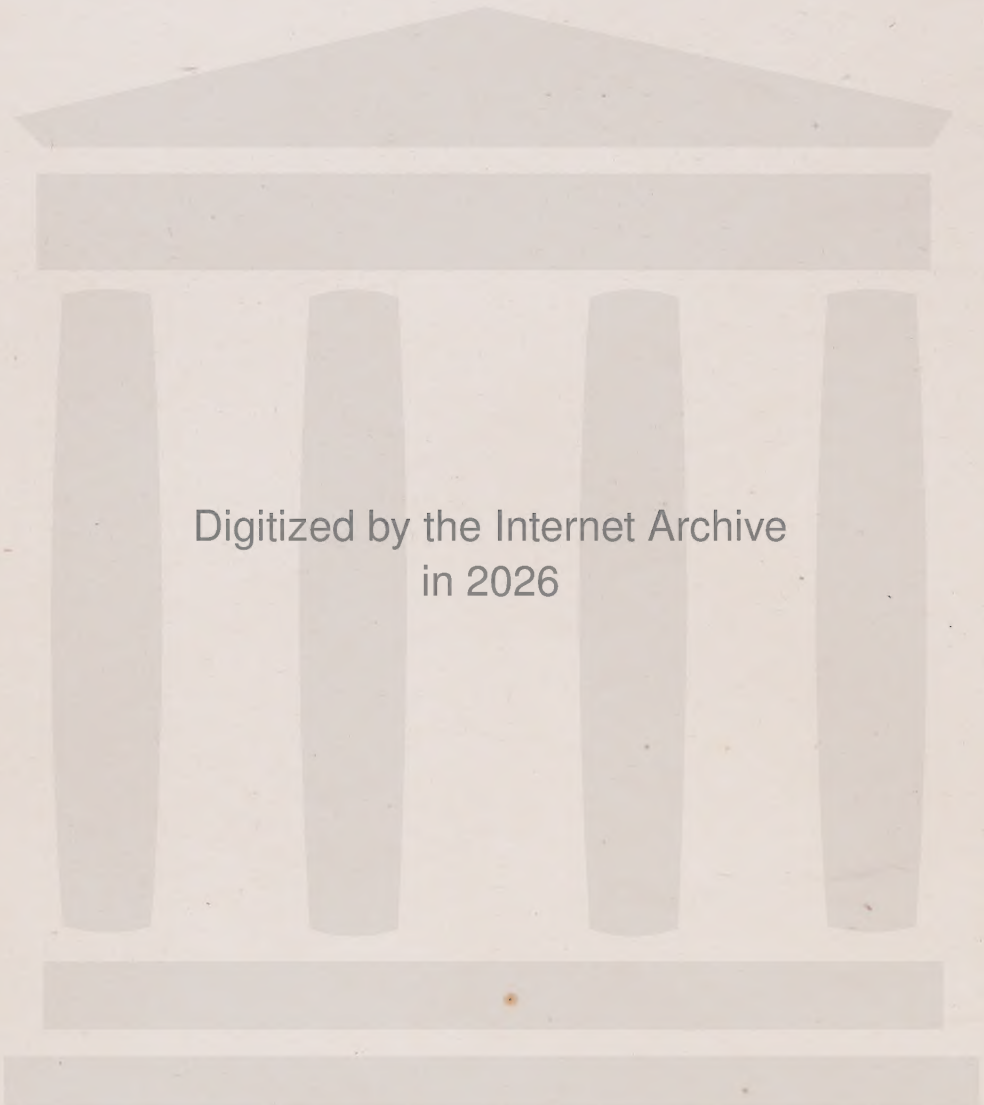

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DEPARTMENT OF COMMERCE AND LABOR

BULLETIN

OF THE

BUREAU OF FISHERIES

VOL. XXVIII

1908

IN TWO PARTS—PART I

GEORGE M. BOWERS
COMMISSIONER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

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PROCEEDINGS OF THE FOURTH INTERNATIONAL FISHERY CONGRESS: ORGANIZATION AND SESSIONAL BUSINESS, PAPERS AND DISCUSSIONS

HELD AT WASHINGTON, U. S. A. : : : SEPTEMBER 22 TO 26, 1908

IN TWO PARTS

PART 1

ISSUED AUGUST, 1910

ANNOUNCEMENT.

The proceedings of the Fourth International Fishery Congress are published herewith in accordance with the instructions of the Congress. By authority of the Secretary of Commerce and Labor and the Commissioner of Fisheries, the Bulletin of the Bureau of Fisheries for 1908 is devoted to this purpose. In thus providing a medium for publication, the Bureau of Fisheries assumes no responsibility for any of the statements or views of the individual members or the Congress as a whole.

HUGH M. SMITH,
Secretary-General.

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Held at Washington, U. S. A., September 22 to 26, 1908

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Prof. Henry B. Ward, University of Nebraska, Lincoln, Nebraska.

BOARD OF TRADE OF GLOUCESTER, MASSACHUSETTS.

John J. Pew, Gloucester, Massachusetts.

BOARD OF TRADE OF WASHINGTON, D. C.

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Charles J. Bell, Washington, D. C.
Scott C. Bone, Washington, D. C.
Clarence F. Norment, Washington, D. C.

CARNEGIE INSTITUTION OF WASHINGTON, DEPARTMENT OF EXPERIMENTAL EVOLUTION.

Dr. Charles B. Davenport, Director of the Laboratory, Cold Spring Harbor, New York.

CHAMBER OF COMMERCE, WASHINGTON, D. C.

Thomas W. Smith, Washington, D. C.
Julius Garfinkle, Washington, D. C.
D. S. Porter, Washington, D. C.
Thomas C. Noyes, Washington, D. C.
William F. Gude, Washington, D. C.

DISTRICT OF COLUMBIA FISH AND GAME PROTECTIVE ASSOCIATION.

Dr. William P. Young, Washington, D. C.
Dr. Theodore S. Palmer, Bureau of Biological Survey, Department of Agriculture, Washington, D. C.
Henry Talbott, Interstate Commerce Commission, Washington, D. C.
Dr. W. S. Harban, Washington, D. C.
Richard Sylvester, Washington, D. C.

FIELD MUSEUM OF NATURAL HISTORY.

Dr. Seth E. Meek, Chicago, Illinois.

LEAGUE OF AMERICAN SPORTSMEN.

Maj. R. R. Raymond, U. S. Army, Washington, D. C.

MARYLAND FISH AND GAME PROTECTIVE ASSOCIATION.

Oregon Milton Dennis, Baltimore, Maryland.

NATIONAL ASSOCIATION OF SCIENTIFIC ANGLING CLUBS.

Dr. R. Johnson Held, New York City, New York.
H. Wheeler Perce, President of the Association, Chicago, Illinois.

NATIONAL ASSOCIATION OF AUDUBON SOCIETIES FOR THE PROTECTION OF WILD BIRDS AND ANIMALS.

William Dutcher, President, New York City, New York.
T. Gilbert Pearson, Secretary, Greensboro, North Carolina.

NATIONAL ASSOCIATION OF GAME AND FISH WARDENS AND COMMISSIONERS.

Carlos Avery, Executive Agent Minnesota Game and Fish Commission, St. Paul, Minnesota.
W. F. Scott, President National Association of Game and Fish Wardens and Commissioners, Helena, Montana.
Charles A. Vogelsang, Chief Deputy California Game and Fish Commission, San Francisco, California.

NEW ENGLAND FOREST, FISH, AND GAME ASSOCIATION.

Richard E. Follett, Boston.
Bayard Thayer, Boston.
Hon. Herbert Parker, Boston.

NEW YORK ZOOLOGICAL SOCIETY.

Charles H. Townsend, Director of the New York Aquarium, New York City.

PENNSYLVANIA FISH PROTECTIVE ASSOCIATION.

Marion G. Sellers, Philadelphia.
William E. Meehan, Harrisburg.
E. D. Hemingway, Philadelphia.
Joseph Johnson, Philadelphia.

PHILADELPHIA AQUARIUM SOCIETY.

Dr. Herman Burgin, President of the Society Philadelphia, Pennsylvania.
Herman T. Wolf, Philadelphia, Pennsylvania.

TUNA CLUB, AVALON, CALIFORNIA.

Charles F. Holder, President, Pasadena, California.

UNIVERSITY OF NEBRASKA.

Prof. Henry B. Ward, Dean of the College of Medicine and Head Professor of Zoology, Lincoln, Nebraska.

WEST VIRGINIA FISH AND GAME PROTECTIVE ASSOCIATION.

L. C. Crile, Clarksburg.
Andrew Price, Marlinton.
E. M. McPeak, Fayetteville.
Anton Reymann, Wheeling.
George E. Stifel, Wheeling.

VI. OTHER MEMBERS.

Dr. Carl L. Alsberg, Associate Professor of Zoology, Harvard University, Cambridge, Massachusetts.
Dr. R. Anthony, Museum of Natural History, Paris, France.
L. F. Ayson, Chief Inspector of Fisheries, Wellington, New Zealand.
John P. Babcock, Deputy Commissioner of Fisheries of British Columbia, Victoria, British Columbia.
O. N. Baldwin, U. S. Fisheries Station, Leadville, Colorado.
Dr. S. P. Bartlett, Superintendent U. S. Fisheries Station, Quincy, Illinois.
Prof. Dr. Arthur Bellini, Commachio, Italy.
Dr. Marcus Benjamin, Editor, U. S. National Museum, Washington, D. C.
Guiseppe Besana, Lombardy Society of Fishing and Aquiculture, Milan, Italy.
Hayes Bigelow, Member American Fisheries Society, Brattleboro, Vermont.
H. C. Bliss, Alaska Packers' Association, San Francisco, California.
Nicholas Borodine lately Chief Specialist in Fish Culture, Department of Agriculture, St. Petersburg, Russia
G. M. Brown, State Fish Commissioner, Detroit, Michigan.
W. O. Buck, U. S. Fisheries Station, Grand Lake Stream, Maine.
H. M. Buller, State Fish Hatchery, Bellefonte, Pennsylvania.
E. N. Carter, Superintendent U. S. Fisheries Station, St. Johnsbury, Vermont.
E. S. Casselman, Kamp Kill Kare, Raquette Lake, New York.
Eugene Catte, Langdon, Kansas.
John K. Cheyney, Member American Fisheries Society, Tarpon Springs, Florida.
Theodore M. Cogswell, U. S. Bureau of Fisheries, Washington, D. C.
R. J. Conway, Director of Belle Isle Aquarium, Detroit, Michigan.
Dr. Jules Cotte, Station of Marine Zoology, Endoume, France.
Prof. W. C. Curtis, University of Missouri, Columbia, Missouri.
Capt. G. M. Dannevig, Director Marine Fish-Hatching Station, Arendal, Norway.
H. D. Dean, U. S. Fisheries Station, Neosho, Missouri.
Dr. Frederick W. D'Evelyn, Alameda, California.
N. T. DePauw, Waverley Farms, Haymarket, Virginia.
A. H. Dinsmore, Superintendent U. S. Fisheries Station, Baker, Washington.
S. W. Downing, Superintendent U. S. Fisheries Station, Put-in Bay, Ohio.
Dr. Irving A. Field, Western Maryland College, Westminster, Maryland.
John D. Figgins, American Museum of Natural History, New York City.
Karl Flégel, Member Imperial and Royal Austrian Fisheries Society, Vienna, Austria.
Prof. Johann Franke, Laibach, Austria.
Dwight Franklin, American Museum of Natural History, New York City.
Charles E. Fryer, Secretary of Board of Agriculture and Fisheries, London, England.
Alfred E. Fuller, U. S. Fisheries Station, Northville, Michigan.
Dr. T. Wemyss Fulton, Aberdeen, Scotland.
J. J. Glennan, U. S. Bureau of Fisheries, Washington, D. C.
H. D. Goodwin, Milwaukee, Wisconsin.
Chester K. Green, Superintendent U. S. Fisheries Station, Cape Vincent, New York.
Prof. Frederic P. Gorham, Brown University, Providence, Rhode Island.
Dr. E. W. Gudger, State Normal and Industrial College, Greensboro, North Carolina.
L. G. Harron, Superintendent U. S. Fisheries Station, Washington, D. C.
Walter E. Hathaway, White Stone, Virginia.
Prof. Dr. Bruno Hofer, Royal Bavarian Biological Research Station for Fisheries, Munich, Germany.
Henry Holt, Publisher, New York City.
Dr. F. M. Johnson, Member American Fisheries Society, Boston, Massachusetts.
R. S. Johnson, Superintendent U. S. Fisheries Station, Manchester, Iowa.
A. G. Keesecker, Superintendent U. S. Fisheries Station, Erwin, Tennessee.
Dr. William C. Kendall, Scientific Assistant, U. S. Bureau of Fisheries, Washington, D. C.
Dr. George Frederick Kunz, with Tiffany & Co., New York City.
G. H. Lambson, Superintendent U. S. Fisheries Station, Baird, California.
Charles Lay, Sandusky, Ohio.
John L. Leary, Superintendent U. S. Fisheries Station, San Marcos, Texas.

Prof. George Lefevre, University of Missouri, Columbia, Missouri.
Prof. Edwin Linton, Washington and Jefferson College, Washington, Pennsylvania.
E. F. Locke, Superintendent U. S. Fisheries Station, Woods Hole, Massachusetts.
Samuel Lovejoy, U. S. Fisheries Station, Bullochville, Georgia.
Frederic A. Lucas, Curator in Chief of the Museum, Brooklyn Institute of Arts and Sciences, Brooklyn, New York.
M. C. Marsh, Agent at the Alaska Salmon Fisheries, Bureau of Fisheries, Washington, D. C.
Prof. S. Matsubara, Director of the Imperial Fisheries Institute, Tokyo, Japan.
W. L. May, Denver Convention League, Denver, Colorado.
Frank Miller, Put-in Bay, Ohio.
Roy W. Miner, Assistant Curator, American Museum of Natural History, New York City.
Henry O'Malley, Superintendent U. S. Fisheries Station, Clackamas, Oregon.
William Palmer, U. S. National Museum, Washington, D. C.
Prof. George H. Parker, Harvard University, Cambridge, Massachusetts.
Edward E. Race, Superintendent U. S. Fisheries Station, Green Lake, Maine.
Casimir Raveret-Wattel, rue des Acacias, 20, Paris, France.
Dr. Jacob Reighard, Professor of Zoology, University of Michigan, Ann Arbor, Michigan.
Paul Reighard, University of Michigan, Ann Arbor, Michigan.
Robert K. Robinson, Superintendent U. S. Fisheries Station, White Sulphur Springs, West Virginia.
Al. Rosenberg, Spring Brook Trout Company, Kalamazoo, Michigan.
W. H. Safford, Conneaut Lake, Pennsylvania.
Dr. George G. Scott, College of the City of New York, New York City.
George A. Seagle, Superintendent U. S. Fisheries Station, Wytheville, Virginia.
William P. Seal, Aquarist, Delair, New Jersey.
Hon. George Shiras 3d, Stoneleigh Court, Washington, D. C.
G. E. Simms, 61 Lamb's Conduit, London, W. C., England.
A. Sölling, Commissioner of Danish Fisheries Department, London, England.
John I. Solomon, Civil Engineer, 51 West Eighty-first street, New York City.
L. B. Spencer, New York Aquarium, New York City.
M. F. Stapleton, Superintendent U. S. Fisheries Station, Mammoth Springs, Arkansas.
Charles H. Stevenson, U. S. Bureau of Fisheries, Washington, D. C.
W T. Thompson, Superintendent U. S. Fisheries Station, Leadville, Colorado.
E. A. Tulian, Chief of Fish-cultural Section, Ministry of Agriculture, Buenos Aires, Argentina.
Dr. Antoine Valle, Secretary-General of Austrian Society of Marine Fishing and Fish Culture, Trieste, Austria.
Eugene Vincent, Fish Culturist, Trocadero Aquarium, Paris, France.
Claudius Wallich, Field Superintendent, U. S. Bureau of Fisheries, Washington, D. C.
B. O. Webster, Bellefonte, Pennsylvania.
Andrew R. Whitaker, Phoenixville, Pennsylvania.
R. Tyson White, Brooklyn, New York.
E. C. Whitman, Board of Trade, Canso, Nova Scotia.
Dr. H. V. Wilson, Professor of Zoology, University of North Carolina, Chapel Hill, North Carolina.
S. G. Worth, Superintendent U. S. Fisheries Station, Edenton, North Carolina.
Paul Zirzow, Oderbergerstrasse 56, Berlin, Germany.

REGULATIONS.

1. Object of the Congress.

The congress will deliberate on all important affairs concerning fishing and fish culture, and will submit propositions and memorials to governments and to provincial and local authorities.

2. Members of the Congress.

The membership of the congress will consist of government, state, and provincial representatives, delegates from home and foreign societies, corporations, and personages invited by the management of the congress, and persons at home and abroad who are deemed to have an interest in the purposes of the congress and express a wish to take part in it.

3. Rights to Members.

All the members of the congress have the right to vote, to participate in the discussions, and to make independent propositions. In case a corporation should be represented by several delegates, the members of this delegation have the right to only one vote, which shall be cast by the delegate designated to the presiding officer. The delivery of the card of admission gives to members the right to take part in all the enterprises and excursions projected by the congress, to receive all the publications, and to wear the insignia of the congress. The members of the congress are required to conform to its regulations and decisions.

4. Organization of the Congress.

The congress will follow officially the preceding international fishery congresses, and will conform to the decisions for the regulation of the international fishery congresses decreed at Paris in 1900. The president and the secretary-general of the congress will be nominated by the United States Bureau of Fisheries; the vice-presidents will be elected by the congress from among its members.

5. Elections and Resolutions of the Congress.

All the resolutions of the congress are adopted by an absolute majority of the members present having the right to vote. (See sec. 3.) In case of division the president's vote will decide. Elections take place by ballot. Formal propositions and resolutions intended for the consideration of the congress should be in the hands of the local committee by August 1, 1908. The committee will decide on the admission of such propositions; but in case of rejection it is required to make known to the congress the reasons therefor.

6. Resources of the Congress.

The resources of the congress consist of a special appropriation by the Congress of the United States, of voluntary contributions from interested persons, and of membership fees fixed at $2 for each person. In the case of official representatives of governments the membership fee is remitted.

7. Method of Debate.

All the debates of the congress take place in full assembly. The official language is English, but in presenting papers and in debates members have the right to use also the French, German, or Italian language.

The meetings will be presided over by the president or vice-president, who will conduct the debates according to the established order. The president, on yielding the chair, may himself take part in the debates. The duration of the discussion of a subject will be regulated by the extent of the programme and will be communicated to the assembly before the commencement of the debate. Members desiring to speak will inscribe their names and subjects during or after the reading of papers, and the president will call on them to speak in the order of their inscription.

A member may speak only twice on the same subject in the same meeting, personal remarks and corrections excepted. The motion for the close of a debate must immediately be put to a vote; this motion once accepted, only the members who have previously asked recognition may speak. The author of a proposition or paper shall at the end of the debate be recognized for a final résumé.

8. Minutes and Publications.

Minutes will be prepared on all the proceedings of the congress and will contain the reports and debates in brief and in extenso. The full transactions of the congress will be published as soon as practicable after the final adjournment.

9. Additional Regulations.

The local committee of organization will make such further regulations as may be necessary for the proper conduct of the work of the congress.

FOURTH INTERNATIONAL FISHERY CONGRESS.

WASHINGTON, U. S. A., 1908.

SESSIONAL BUSINESS.

PRELIMINARY MEETING, TUESDAY, SEPTEMBER 22.

DEPARTMENT OF STATE.

The foreign delegates and others convened in the Diplomatic Room of the Department of State at 9.30 a. m. and were received by the Assistant Secretary of State, Hon. Alvey A. Adee.

Secretary ADEE. Gentlemen, I have much pleasure in greeting you. It would have been Secretary Root's privilege to meet you, but he is detained at his summer home, in northern New York, and has asked me to welcome you in his name. Falling on me at the last moment, this agreeable duty finds me unprepared to make a formal address. With your kindly indulgence, I venture to offer a few desultory remarks.

Your mission is beneficent. It deals with a phase of the world-old yearning for the conquest of the sea. From Salamis to Trafalgar, from Trafalgar to our own day, the peoples have been rivals for its mastery. Not alone have their mighty fleets striven for supremacy, but their traders have sought to acquire its commercial control for their own advantage. But this keen contest has been for domination upon the face of the waters. Beneath the surface lie other and nobler prizes to be won. We seek those prizes not as embittered antagonists, but as associates in the interest of the great solidarity of mankind.

Above the problem of naval and commercial supremacy is the greater problem of the sustenance and maintenance of the peoples. Without the farmer, the stock raiser, the miner, and the fisherman, there could be no wide-reaching empires, no armies, no navies, no marvelous progress in civilization, no development of culture or science, for the producers supply the means by which all these things are done. It is through the producers, the men who wring from the earth and the seas the means of supporting existence itself, that national life is begotten and developed. It is by the abundance of the producers' returns that the world's prosperity may be measured.

It was said long ago, by a philosopher of the mythical Commonwealth of Brobdingnag, that whoever could make two ears of corn or two blades of grass

to grow where one grew before would be a benefactor of mankind. How many fold greater would be he who, leaving the fertile land for the yet more fertile ocean, should develop the life-sustaining harvest of the waters in ever increasing abundance, for the benefit of all the world in generous equality.

Your purpose is a great one, and in the effort to accomplish it you meet as fellow-workers toward the general welfare. I wish you godspeed in your work.

OPENING SESSION, TUESDAY, SEPTEMBER 22.

NATIONAL GEOGRAPHIC SOCIETY HALL.

The congress was opened at 10.30 a. m. by Hon. George M. Bowers, chairman of the local committee of organization and Commissioner of Fisheries of the United States.

Commissioner BOWERS. Ladies and gentlemen, as Commissioner of Fisheries and chief of the Bureau primarily responsible for the assembly of the Fourth International Fishery Congress in the city of Washington, I do now call this meeting to order.

It gives me great pleasure to present to this meeting the Hon. Oscar S. Straus, Secretary of Commerce and Labor, who will deliver an address of welcome to the congress in behalf of the Government of the United States.

Secretary STRAUS. Mr. Commissioner, ladies, and gentlemen, it is a great pleasure and a high privilege, as head of the Department of Commerce and Labor, of which the Bureau of Fisheries forms an important part, to welcome you heartily to this the Fourth International Fishery Congress.

The subject of fish as an article of food and as an industry, and I might say amusement, is one of the oldest and dates back to the earliest history of mankind. Even in Isaiah we read, when foretelling or forecasting the dissolution of Egypt, "The fishers also shall mourn, and all they that cast angle into the brooks shall lament, and they that spread nets upon the waters shall languish," showing that even in those early times the fish and fishers were held to be one of the important considerations of mankind.

The question of food, and of fish as an important article of food for mankind, was perhaps even more important in the dawn of history than it is to-day, in that the articles of food, the contributions to what made up the sustenance of mankind, were not so extensive as they are, and as they became, as nations became more enlightened and their needs became greater.

Last spring the President of the United States, who as a historian is one of the greatest that this country has known, and whose horizon is therefore that of a historian, called together in conference the governors of our states for the purpose of considering the conservation of our natural resources—the forests, the lands, the waters, the minerals—recognizing, as all students

of these important subjects must, that we are drawing heavily upon that valuable capital, the natural resources of the land and of water, and that, looking forward to the generations that are to follow us, it becomes not only our duty, but a necessity of safe policy, to see that these great blessings that have come to us shall be handed down to those generations not exhausted in selfishness or wasted in ignorance, but as little impaired as human science and human ingenuity can provide for. In full accord with that wise and statesmanlike policy is the meeting of a congress such as this, for one of the great natural resources is fish, one of the important articles of food and one of the healthiest.

There is perhaps no more significant sign of the unity of the enlightened people of the world, of the brotherhood of mankind, than these international congresses for the purpose of promoting the welfare and happiness of the people of all nations. Here in this city now are two such international congresses meeting. Not far from here are gathered many of the scientists of the world, the great healers, the physicians, who have come together in order to compare notes, to study, to advance the knowledge that will eliminate the greatest enemy of mankind, popularly known as the "great white plague." And here are assembled men from every State, delegates from foreign countries, in order to compare notes, to exchange ideas, to discuss the various phases of the science with which they are connected, for the purpose of promoting the culture and the propagation of one of the great articles of food upon which mankind subsists. The purpose and object are worthy of your consideration.

To us in this country fish and fisheries have been of the highest importance since the earliest period of colonization. Our Pilgrim Fathers, of whom we are very proud—so proud that the whole United States might be divided into two classes, those who are descended from them and those who claim to be descended from them [laughter and applause]—for the first two years they subsisted almost entirely on fish; and I leave it to you, gentlemen of science, that perhaps that is the reason why their descendants have shown such wonderful mental powers [laughter], such aggressiveness, are so rich in brains—because their original progenitors lived for two years on fish. [Applause and laughter.]

Another point: The earliest commerce of the settlers on the New England coast was fish and lumber. Now, fish is dried, salted, and cured, and I am told that fish eaten in that way stimulates thirst very much. [Laughter.] Was it, perhaps, on that account that the early commerce with the West Indies—the exportation of cured fish—resulted in the bringing back from the West Indies of rum [laughter], sugar, and molasses? They go well together. [Laughter and applause.] A very fair exchange. Bismarck says that "the logic of the historian is as exacting as Prussia's accounting office." Let us see. One of the

great political questions that is sweeping over New England to-day is prohibition, and I suppose the reason it finds so much favor in New England is because of this, for the New Englanders are nothing if they are not historical. Historically speaking, having in mind the enormous amount of rum that they imported from the West Indies, they can say, "O, Lord, we have had our fill." [Laughter and applause.]

I need not point out to you that the quest for fish has inspired, has brought up, some of the most intrepid navigators, who, in search of fish, have become the great discoverers. It is said, with historical accuracy that I neither admit nor deny, that the continent was first discovered, or at least the northern portion of it, by the Norse fishermen. You know that the Cabots, in their discoveries, came back and placed great emphasis upon the fact of the Newfoundland cod. The cod is almost a national emblem for a part of this country, and well it may be.

Gentlemen, I know you are scientific, and you do not want to hear from me on questions of history; but one of my chief objects in talking to you, who know so much about fish from its scientific side, is to conceal from you my ignorance of the subject [laughter], and if I have succeeded in doing that I have largely accomplished what I came for.

I wish, in conclusion, to say that we welcome you most heartily, especially you who have come to us from foreign shores. We know that you have much to teach us, and perhaps we may have a little something to teach you in return. Be that as it may, whatever we have is yours. We are united with you in this great and noble work, in uniting our experience, our scientific knowledge, for the purpose not only of conserving this very important and great item of food for mankind, but of increasing it, propagating it; and no more important subject can engage the attention of scientific and practical men of all nations. [Applause.]

The CHAIRMAN. We have with us one of the Commissioners of the District of Columbia and city of Washington—one of our governors—and it gives me great pleasure to present the Hon. Henry L. West, who will extend a welcome to the congress on behalf of the city of Washington.

Commissioner WEST. Mr. Commissioner, members of the congress, ladies, and gentlemen, the citizens of the District of Columbia add, through me as their representative, to the very warm and sincere words of welcome just eloquently uttered by the Secretary Commerce and Labor.

Your meetings hitherto, I believe, have been held on shores foreign to us, and it is peculiarly appropriate that here in the United States you should hold your session in the capital of this great American Republic. We may be, as the Secretary has said, ignorant of the scientific terms and other technical knowledge regarding fish, and yet we are not unaware of the great results which are already a part of the enviable history of this congress nor of the high aims which stimulate you to still further accomplishment. And we believe and hope

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that your deliberations here will add still more to the splendid record you have already attained.

The work of this congress appeals with peculiar force to the popular mind. The propagation and culture of the food fishes, as well as the preservation of the important species which would become extinct but for the care, zeal, and knowledge which you exercise, offers to every man a most attractive field and brings its large reward in the consciousness of doing good for all mankind. It is, therefore, with especial pleasure that we welcome you to Washington, in the continued and increasing development of your practical work.

We have not here, in a new country and a new city, the traditions and the histories which invest foreign capitals with so much charm; and yet you will find here in Washington many things that we hope will be of real interest to you. Yonder white-domed Capitol must dwell forever in your memories as an impressive and inspiring picture; the White House is the embodiment of our democratic life; and the tomb at Mount Vernon, when you stand beside it, whether you be an American or a foreigner, must compel your respect, if you admire in the human race the characteristics of patriotic courage and devotion. And, above all, in the laboratories and museums here you will have ample opportunity for the facilitation of that study in which you are engaged and which has earned for you the commendation of the world.

I can not, I assure you, talk either as eloquently, as confidently, or with as much experience regarding "rum and molasses" as my friend Secretary Straus [laughter], but I can join with him, and do join with him, in welcoming you to this beautiful capital, which has grown in hardly a century—in fact, the new Washington is but twenty or twenty-five years old. We can join together in welcoming you here, in expressing the hope that your deliberations may be of such advantage to you, that your experiences here may be so pleasant, that the hospitality which we will try to extend to you may leave so warm a spot in your hearts and thought, that when you leave you will have had awakened a desire to reassemble as soon as possible in the capital of the United States. [Applause.]

The CHAIRMAN. The president of the American Fisheries Society is with us, and will now extend a welcome in behalf of that society. I take pleasure in presenting Dr. Hugh M. Smith.

Doctor SMITH. Mr. Chairman, ladies, and gentlemen, it is not inappropriate that on this occasion an opportunity should be afforded the American Fisheries Society to join with the United States Government and the city of Washington in extending a welcome to those who have come from afar to participate in this gathering of the fishermen of all nations; for the society feels that its objects, its accomplishments, and its affiliations entitle it to a voice in these proceedings.

Forty years ago fish culture was a very absorbing theme among a small band of American pioneers by whom the creation of a fishery bureau under

government control was strongly advocated. A few years later, when these fish lovers had banded themselves together in a society, they continued their agitation and exerted a decided influence in inducing Congress to establish the national bureau of fisheries. A little later, when it was seen that the law incorporating the bureau contained no provision for the artificial propagation of food fishes, this same society on whose behalf I have the honor to speak persuaded Congress to authorize and make special appropriation for fish culture, which has since been conducted on a yearly increasing scale and has become the most important branch of the fishery work of the government.

This society was thus intimately concerned in inaugurating and shaping the course of the public fishery service of the United States, and it has continued to exert a potent influence in federal and state fishery affairs. It is the representative fishery organization of the Western Hemisphere, and has just held its thirty-seventh annual meeting. Its 400 active members include nearly all national and state fishery officials, as well as men engaged in private fish culture for pleasure or pecuniary profit; hardy fishermen of our seas, lakes, and rivers; managers and employees of fishing and fish-preserving companies; university professors whose biological studies deal with the inhabitants of the water; enthusiastic disciples of Izaak Walton; ultra-fastidious scientific anglers who would rather tie an artificial fly properly and cast a line gracefully than catch the largest trout—in short, all sorts and conditions of that widely distributed variety of the human species which we may call *piscatorius*.

The society has been pleased to include in its honorary and corresponding membership many who have attained prominence in various branches of fishery work in Europe, Asia, and America. A number of these members are here to-day with our other colleagues; and perhaps the greatest benefit that will accrue to our people from this congress will come not from the formal papers and discussions, important as they may be, but from the opportunity thus afforded to meet personally and informally exchange experiences with our colaborers from other lands.

Therefore, the American Fisheries Society wishes to express its great pleasure that you have come among us, and to extend to you a cordial greeting from every state and territory of this vast country; but we prefer to regard you not as representatives of great sovereign powers and influential foreign societies and organizations, but as fellow-citizens of that cosmopolitan domain where fish is king and where, as loyal subjects, we labor together for the good of the royal family and all of its aquatic relatives.

The CHAIRMAN. I have to announce that in pursuance of the established custom, those extending the invitation to meet in Washington have selected as president of the Fourth International Fishery Congress Dr. Hermon C. Bumpus, Director of the American Museum of Natural History, in New York. A motion to ratify this selection is now in order.

Dr. HEINRICH VON KADICH. I move that the nomination be ratified.

[The motion was duly seconded.]

The CHAIRMAN. You have heard the motion. As many as are in favor of the ratification say "Aye;" the contrary, "No." The motion prevails.

I have to announce further that Dr. Hugh M. Smith, Deputy Commissioner of the United States Bureau of Fisheries, has been nominated for secretary-general. A motion to ratify this selection is in order.

Lieut. RADLER DE AQUINO. I move that the nomination be ratified.

The CHAIRMAN. As many as are in favor of the ratification of this selection say "Aye;" the contrary, "No." The "ayes" have it, and Doctor Smith is duly elected secretary-general.

The permanent officers have now been selected, and I surrender the chair, with expression of the hope that the deliberations of this congress will be pleasurable and profitable, and that when you go hence, at the conclusion of the meeting, you will carry with you the feeling that the long journey many of you have made has not been made in vain. I wish you happiness and success. Doctor Bumpus, will you come forward? [Applause.]

Doctor BUMPUS. On assuming the chair, I will ask if any one is prepared to acknowledge the courtesies that have been extended to us by the Honorable Secretary of Commerce and Labor, by the Honorable Commissioner of Fisheries, and by the Honorable Commissioner of the District of Columbia?

Dr. P. P. C. HOEK (Holland). You will please excuse my poor English, gentlemen. I might address you in another language as well, yet I believe that though my English is not quite pure, still most of you might understand me better than if I addressed you, say, in Dutch.

Gentlemen, I have been asked, and I have accepted the invitation with great pleasure, to address, first, to the United States Government, and especially the Bureau of Fisheries of the Department of Commerce and Labor; in the second place, to the District of Columbia; and in the third place, to the American Fisheries Society, the hearty thanks of the congress for this splendid and extremely agreeable reception here in Washington. But it is not only for that reception—it is especially for the excellent way in which this congress has been prepared—that we are extremely grateful to the secretary-general, of course, in the first place, and to the president, and to all the gentlemen who have given themselves the trouble to assist these other gentlemen in this matter.

Ladies and gentlemen, may I use this opportunity to tell you that a few days ago I came across an American book, a book published, I think, about thirty-five years ago and then studied by me with great pleasure on the other side, a book which I have not seen since? It was a book by Draper, and the title of that book was "The History of the Struggle between Religion and Science." It is not for the question of that struggle that I quote that book, but it is because the

formulation brought me to think about another struggle, a struggle between—let me see—human industry on one side and nature on the other side. When I say "human industry" I mean the whole of what man does—the building of great cities, the river pollution, the erection of large manufactories, navigation, all kinds of industry, mining, and much more—I mean that altogether. How does that human industry compete with nature? We soon find out that to a large extent human industry has been extremely disadvantageous—I might use a stronger word—to nature. It is true that human activity did what it could, in some cases more, in others less, to make good again what was spoiled by man on the other side. A German poet said, "Die Erde ist schön überall, wo der Mensch nicht hinkommt mit seiner Qual." You might say that in English, "Beautiful is the earth everywhere where man does not come to spoil it."

You understand, now, what I mean; I intended to say that it will be very nice to have another book written, another Draper writing a book on that struggle between industry and nature; and when such a book ever will be written I am perfectly sure beforehand that you will find in that book pages—no, whole chapters—telling of the excellent and most efficacious way in which that struggle has been taken up here in your country. And when we were honored with the invitation to come to your United States, and were glad to receive that invitation, it was, in the first place, because we enjoyed beforehand, and were sure to enjoy making acquaintance with, your excellent methods of ameliorating the fisheries in your waters.

This is nearly all I have to say to you, but when I repeat my thanks for this reception, and for the invitation, I lay stress upon the fact that it is especially because we so extremely admire the excellent way in which you have tried to propagate and to protect the fisheries, to do what you could by artificial and natural culture to promote the great industry in which we all here are so highly interested.

The PRESIDENT. Those having the arrangement of the affairs of the congress in hand have asked me to make certain announcements, particularly in regard to the appointment of officers and committees, and with your kind permission I will make them at this time. First, I have the honor to propose the following list of vice-presidents:

As the first vice-president, and representing the Netherlands, Dr. P. P. C. Hoek, Scientific Fishery Adviser of the Dutch Government, Harlem.

Austria, Dr. Heinrich von Kadich, Councillor of Administration, Department of Forestry and Domain, Vienna.

Brazil, Lieut. Radler de Aquino, Naval Attaché of the Brazilian Embassy, Washington, D. C.

Canada, Prof. Edward E. Prince, Dominion Commissioner of Fisheries, Ottawa.

China, Dr. Wei-ching W. Yen, Second Secretary Imperial Chinese Legation at Washington, D. C.

Guatemala, Dr. Ramon Bengoechea, Consul-General of Guatemala, New York City.

Italy, Prof. Decio Vinciguerra, Director of the Royal Fish-cultural Station, Rome.

Japan, Dr. Tasaku Kitahara, Imperial Fisheries Bureau, Department of Agriculture and Commerce, Tokyo.

Mexico, Hon. José F. Godoy, Chargé d'Affaires ad interim, Mexican Embassy, Washington, D. C.

Peru, Dr. Robert E. Coker, Fishery Expert of Peruvian Government, Lima.

Roumania, Dr. Gregoire Antipa, Inspector-General of Fisheries, Bucharest.

Sweden, Dr. Oscar Fritiof Nordqvist, Superintendent of Fisheries, Lund.

German Fisheries Society, Dr. Walther Naumann, Lipsa, near Ruhland, Germany.

Royal Geographical Society, England, Mr. O. T. Olsen, Grimsby, England.

United States, Dr. Richard Rathbun, Assistant Secretary Smithsonian Institution and member of Permanent Commission of International Fishery Congresses, Washington, D. C.

[Moved and duly seconded that the nominations for vice-presidents be ratified.]

The PRESIDENT. Those in favor will signify by saying "Aye;" those opposed, "No." It is carried. The ratification will be duly recorded by the secretary.

I announce certain committees, and particularly a committee that will attend to the arrangement of the programme. There are about 100 papers that have been submitted, and naturally there is not sufficient time for the presenting of all these papers in extenso. The adoption of some scheme that will be satisfactory to the largest number, and an arrangement of the programme from session to session, has been found essential. This, it was thought, might well be delegated to a representative committee, which might consist of the following: Mr. Charles E. Fryer, Dr. Leonhard Stejneger, and the secretary-general. If these gentlemen will then kindly convene in this room at the time of the adjournment this morning, the first meeting of that committee can be held, provided the appointment meets with your approval.

Another committee—a committee on awards—will have a great deal of work to do. It was thought wise to have the committee on awards practically a number of small committees. The subjects for which awards have been arranged group themselves under five headings, and there will be announced at the session this afternoon those gentlemen whom we would like to have serve on the international committee on awards. At that time there will also be

given a full statement of the conditions under which these awards have been given and a list of the competitors.

For a committee on resolutions, these names are suggested: Prof. Edward E. Prince, Dr. Tarleton H. Bean, and the secretary-general.

Is there miscellaneous business to come before this meeting?

Dr. HENRY F. MOORE. There appears to be no other business to be presented. I therefore move that we adjourn, Mr. President, until 2 o'clock this afternoon, when the meeting will be held at the New Willard Hotel.

The PRESIDENT. Doubtless all understand that our regular place of meeting will be in the large banquet hall, on the top floor of the New Willard Hotel. Our headquarters will be there. At the anteroom you will find notice of the places at which you may receive your mail, in case it has been sent in care of the local committee. You will also find there some one who will act as interpreter and general adviser, and some one who will have charge of the local bureau of information. The meetings will be held promptly at the times announced. At 2 o'clock this afternoon the meeting will be called to order. We will now adjourn to meet at that hour.

Thereupon, at 12.05 p. m., the congress adjourned.

AFTERNOON SESSION, TUESDAY, SEPTEMBER 22.

NEW WILLARD HOTEL.

The congress was called to order by the president at 2 o'clock.

The PRESIDENT. The chair would make the following announcements:

With reference to the committee on awards, you will remember that the list of prizes has been printed and circulated, and there are some 18 prizes. The committee on awards will consist of the following subcommittees:

For prizes numbered 3, 7, and 8, Dr. Oscar Nordqvist, Dr. T. S. Palmer, Maj. Richard Sylvester, Dr. B. W. Evermann, and Dr. W. S. Harban.

For prizes numbered 1, 5, 6, 11, 14, and 15, Dr. Decio Vinciguerra, Dr. E. A. Birge, Dr. F. B. Sumner, and Dr. T. Kitahara.

For prize numbered 17, Dr. H. von Kadich, Dr. H. B. Ward, and Dr. R. E. Coker.

For prizes numbered 9, 10, 12, 13, and 16, Dr. P. P. C. Hoek, Mr. W. E. Meehan, and Mr. J. W. Titcomb.

For prizes numbered 2, 4, and 18, Dr. Gregoire Antipa, Dr. S. E. Meek, and Dr. F. W. True.

And I would request the chairmen of these respective committees kindly to apply to the secretary-general of the congress, Doctor Smith, by whom you will be given a list of the papers and the papers themselves that have been submitted to the congress in competition for these awards.

The committee on programme found themselves somewhat in doubt in regard to the wisest way in which to arrange the programme. It seems that we have two kinds of papers—some that are submitted in competition and some that are not submitted in competition. The committee on programme have felt that it was to the best interests of the congress to have the papers presented here irrespective of whether they were or were not offered in competition; and, feeling that they had the confidence of the members of the congress to the effect that they would be quite impartial in selecting papers for presentation, have decided, so far as their work is concerned, to arrange the programme for the successive sessions without respect to the question of competition. The question of competition is left to an entirely different committee or committees.

The committee on programme, moreover, have felt that it would be fair to all that the time limit for papers presented should be fifteen minutes, unless voted an extension by the congress. It was also felt that discussion would be stimulated if the time for those discussing the papers presented should, in the initial case, be limited to three minutes. Therefore, the chair will follow the instructions of the committee, unless it is instructed by the congress to the contrary.

The chair has been asked to make certain announcements.

All members of the congress who have not received invitations, cards, et cetera, to the President's reception, Secretary Straus's reception, the lecture at the National Geographic Society, and all other functions connected with the congress, should call at room 1001, the anteroom in the New Willard, to secure these cards of invitation; and I beg of you to keep in touch with room 1001. It is practically our headquarters between sessions.

The members of the International Fishery Congress and ladies are invited to be the guests of the American Fisheries Society at an informal lunch to-morrow at the Arlington Hotel, at 12 o'clock sharp. This is a lunch given by the American Fisheries Society, the society that adjourned yesterday in order that it might merge its meetings with yours.

The programme that has been submitted for the meeting this afternoon has been roughly outlined upon the blackboard. Mr. Olsen has consented to open the congress with his paper, "International Regulations of the Fisheries on the High Seas." Mr. Olsen, will you kindly come forward to the platform?

Mr. O. T. Olsen (England). Ladies and gentlemen, I rather regret that I should be called upon so early to read the paper which I had prepared but not quite finished; and should it be disjointed I hope you will forgive me and let me down gently, for I have come a long way on short notice, and therefore have not been able to finish what I intended to do.

The paper relates to a very extensive subject, and to do justice to it here would take up considerably more time than we shall be able to afford, as there

are many speakers to come after me. I think the best plan will be to begin with the territorial waters or sea-fishery limits.

[Mr. Olsen's paper appears on pages 77–82.]

The PRESIDENT. Mr. Fryer has consented to open the discussion on this paper—the initial paper of the congress.

[Mr. Fryer's remarks appear on page 83.]

The PRESIDENT. I am sure all Americans feel with me the great sense of gratification that it is to be permitted to listen to and to meet those with whose work we are so familiar, but with whom we have not heretofore had the privilege of personal acquaintance. I feel like thanking personally both of the gentlemen that have opened the discussion, and I am sure that we all feel the same way about it.

The paper that has been presented is now open for general discussion. Are there any contributions from the floor?

[Dr. B. W. Evermann thereupon addressed the congress in continuation of the discussion. His remarks appear on page 85. Mr. A. Kelly Evans followed, and his remarks appear on page 87.]

The PRESIDENT. Are there others who will contribute to this discussion?

[Mr. John J. Pew then spoke on the regulation of beam trawling, and his remarks will be found on page 88. The discussion of the same subject was continued by the president, Doctor Hoek, Mr. North, and Mr. Fryer, whose remarks appear on page 89.]

The PRESIDENT. We are still discussing the first paper on the programme. Are there others who will contribute to the discussion?

Mr. C. H. WILSON (New York). Mr. President, I would like to get into this discussion for just a minute.

[The remarks of Mr. Wilson on the condition of the fisheries of the Great Lakes are given on page 89. He was followed by Mr. Henry Hinrichs, who spoke on the same subject and whose statements may be found on page 90.]

The PRESIDENT. Are you now ready to proceed with the second paper? Is Professor Prince here, please? Will Professor Prince rise? [No response.] Then the next paper is one to be submitted by Mr. Hathaway. The paper is entitled "Effects of Menhaden Fishing upon the Supply of Menhaden and of the Fishes that Prey upon Them," by Walter E. Hathaway, of Whitestone, Virginia.

[Mr. Hathaway's paper is printed on pages 269–277, and was briefly discussed by the president and Dr. Hugh M. Smith. See page 277.]

The PRESIDENT. The secretary has one or two announcements to make.

The SECRETARY-GENERAL. I desire to call attention to a typographical error in the invitation card to the moving pictures which will be displayed by courtesy of the New England Forest, Fish, and Game Association. The card reads "September 26th," but is intended to read "September 22d." The function is this evening.

These very beautiful bouquets that decorate our desks have been presented by the exceedingly efficient chairman of our local entertainment committee, and are sent to this meeting with the compliments of the White House, with the further request that they be given to the ladies in attendance when we adjourn. [Applause.]

I have great pleasure in reading this cablegram from Prof. Dr. Franz Steindachner, the president of the Third International Fishery Congress, dated Vienna, September 22:

"An old lover of fishes regrets his absence and sends best wishes." [Applause.]

[The congress took a recess of five minutes, after which the discussion of Mr. Hathaway's paper on the menhaden was resumed, and Mr. Cooper and Mr. George P. Squires spoke. Their remarks appear on page 278.]

The PRESIDENT. Is Doctor Coker here? [No response.] Then is Dr. I. A. Field here? [No response.] Then Dr. George W. Field, of the Massachusetts Commission, who has spent a great deal of time on the various problems connected with the lobster.

[Doctor Field spoke on "Lobsters and the Lobster Problem in Massachusetts." His remarks are given in full on pages 209–212. The discussion which followed (see p. 213–217) was participated in by the president, Mr. H. T. Root, Mr. W. H. Boardman, Mr. James Donahue, Mr. Fryer, and Dr. George W. Field.]

The PRESIDENT (at the conclusion of the discussion on lobsters). Are there other contributions? If not, I will read a communication that has been received by the Rhode Island Commission of Fisheries from Robert Aldrich & Co., fish trappers and trawlers, of Wickford, Rhode Island. The letter is dated September 18, 1908, and is as follows:

> It is our belief that the continual firing for a week of the heavy guns at Fort Greble has a serious effect on the squeteague fishing in West Bay. Last June the squeteague were entering the bay just before the militia went to the forts, and for some few days we had good fishing. As soon, however, as the firing commenced at Fort Greble the catches became very much smaller and by the end of the week we got very little. We can not prove, of course, that the firing was the cause of this, but we believe that it had a good deal to do with it. We do know that a school of menhaden in the vicinity of Dutch Island will "shower" every time a big gun is fired. Squeteague enter the bay in large schools and they must pass close to Dutch Island. The militia go to the forts every year just as the squeteague are at the height of their run, and we think the steady firing has a tendency to drive them back and out of the bay. After the fish have got by the forts and are well distributed in the bay the firing would probably have little effect—that is, about August 1. We have it on pretty good authority that in one of the large bays in Ireland the fishing has been very poor for a number of years since the battle ships have had their target practice there, while in the other bays the fishing has been normal. We write this hoping that perhaps the question may be discussed and more facts discovered at the coming fishery congress.

The PRESIDENT. Perhaps some of the members present have information in regard to the effect of heavy firing upon fish.

Mr. HATHAWAY (Virginia). Mr. President, I would like to make a statement in regard to that. A year or two ago our fleet came up into the Chesapeake Bay and made their headquarters off Tangier Island, about the center of our menhaden fishing. This we believe to be a positive fact, indicated by what we saw and experienced. They were practicing, and our fishing was around within 10 miles; and every day the fishermen would find a school of fish—as the menhaden are a surface fish—and away would go one of those guns and down the fish would go, and not a fish for the poor fisherman. And many of our friends know what kind of oaths our fishermen utter under those circumstances. [Laughter.] We believe, judging from our fleet, according to the estimated catch of the fish by the number of vessels we had at work, that by that fleet coming and practicing for a few weeks, $4,000,000 loss was sustained in our state. It is a fact that the fleet drove every fish away as fast as every gun would go. The fish had just come up there and the fishermen had just got among them, and they absolutely drove away every fish from us; so much so that we petitioned through our Representative in Congress that they withdraw the fleet from our grounds, and I am very proud to say that they did.

The PRESIDENT. May I ask some one in the Bureau of Fisheries whether the government is now making any observations with reference to the effect of gun practice?

Dr. FRANCIS B. SUMNER (Woods Hole Laboratory, Massachusetts). We have some data on that subject—unfortunately not nearly as much as we could have wished for. Nearly all that I shall say is on the authority of Prof. G. H. Parker, who, as many of you know, is a well-known student of animal physiology, and especially a student of the physiology of the sense organs and of reactions to stimuli. Professor Parker several years ago made some investigations in the endeavor to answer the question, Do fishes hear? As many of you may know, there has been a good deal of difference of opinion as to whether fishes hear at all. It was claimed at one time that fishes could hear even such sounds as the shouting of persons on shore, or in a boat, or even the ringing of a bell. There is that classical story, which perhaps some of you have heard, of the monastery in Europe, where a bell was rung periodically and the fishes came up to get their food. A scientist—I do not recall his name—took the trouble to investigate the report and found it to be quite correct. He looked a little further, however, than the ordinary observer, and he found that what the fish really did was to respond to the sight of the approaching person, and not at all to the sound of the bell. The bell had nothing to do with it.

Professor Lee, of Columbia University, also made some experiments upon the hearing of fishes more than ten years ago, and his conclusion was entirely negative. While he granted, of course, that the obvious auditory organ or organs which exist in the ear region of a fish are there for a purpose—in other words, that they have a function—this function he did not believe to be hearing.

Professor Lee came to the conclusion that his fishes did not hear, so far, at least, as he could get any responses from them. Professor Parker, however, working a few years ago in the employ of the Bureau of Fisheries at our laboratory at Woods Hole, proved pretty definitely that certain fishes, at least, did respond to sound stimuli. He put fishes into a moderately small tank in the laboratory and had an apparatus contrived by which he could transmit sound vibrations which would shake the tank and thus the water. By this means he could virtually eliminate mechanical stimuli, and yet allow the fishes to be affected by stimuli which were rapid enough to produce in ourselves auditory sensations. Professor Parker's results led him to believe that fishes could hear to a limited degree. He worked chiefly on a certain small noncommercial fish known as the "killifish" or "mummichog" (*Fundulus heteroclitus*); also on the squeteague, or weakfish.

Now, when this question came up recently as to whether the battleships actually did disturb the fishes on our coast, as has been alleged pretty vociferously in certain quarters, and also whether the motor boats disturb these fishes, naturally the man to whom the Bureau of Fisheries turned for information was Professor Parker. The original intention was that Professor Parker should carry out some experiments with the cooperation of the Navy Department—that is, the Bureau had correspondence with the Navy Department, and an arrangement was made, which, however, unfortunately miscarried. We sent a boat down to the vicinity of No Mans Land, off Marthas Vineyard, where this firing was to take place, but the battleship was not there at the time. Since then other propositions have been made by the Navy Department, and we might perhaps have made an arrangement with them, but the thing was otherwise not practicable at the time. We are in possession, however, of the following data: We had in Woods Hole Harbor this summer one of the large revenue cutters, the *Gresham*. Those cutters, as you know, are, of course, provided with nothing like such heavy guns as are the naval vessels, but still with good big guns, which, at short range, make a concussion unpleasant to people in the neighborhood of them, and, of course, a very loud sound. Professor Parker went across Woods Hole Harbor with his fishes. The gun was pointed at him, firing, of course, a blank charge, and he made observations. The fishes were placed in a little pen of netting, which was floated on the surface of the water. Doctor Parker is so accustomed to observing the reactions of these fishes to stimuli that he would naturally detect even very slight effects, which might not be noticed by a less skilled observer. He took out several kinds of fishes for this experiment. He tried them, first, at a distance of perhaps 300 or 400 yards; next somewhat closer than that, and, finally, almost directly underneath the guns of the vessel. There were absolutely no responses noted on the part of any of these fishes. That, of course, does not prove what a naval

vessel might do; but what a revenue cutter could not do in that line at a distance of 50 feet it is not likely a naval vessel could do a mile or even a quarter of a mile away.

As to the motor boats, Professor Parker got exactly the same results. He used some surface-living fishes, the mackerel among others. This is one of the fishes which, it was alleged, were disturbed most by these noises. So he had fishermen go around with a motor boat, with the discharge out of the water, and also with it turned under the water. In the latter case the sound is "muffled" to our own ears, and yet, of course, strong vibrations must pass into the water and would presumably affect the fish more under those conditions if there was any effect at all. In these experiments, also, there was no response whatever. If the motor boats came near enough and the mackerel saw them, why, "down they went," as the gentleman here has described; but if the motor boats did not come within sight of the fish, but merely made the sound under the water, there was no response whatever.

Of course, these results are not conclusive. It is desired to try these experiments with large guns; but so far this has not been practicable. In the meantime, however, I thought that these conclusions might be of some interest.

The PRESIDENT. What are your wishes in regard to this communication from Messrs. Aldrich & Co.?

Mr. HENRY T. ROOT (Rhode Island). I do not know what has been the experience of the members of this congress generally, but in our section we are having a considerable number of complaints about the firing of the great naval guns, and I am glad the subject has come up. I move that this whole matter be referred to a committee to be appointed by the chair.

The PRESIDENT. You have heard the motion. Is the motion seconded?

Mr. L. L. MOWBRAY (Bermuda). In the Bermudas we have made some experiments with that, and we think it is really due to explosive shells exploding very close to the surface of the water. They found many dead fish. It is a well-known fact that such explosions greatly disturb fish.

The PRESIDENT. The motion has been made and seconded that this matter be referred to a committee. Those in favor of such reference will please signify by saying "Aye;" contrary minded, "No." The motion is carried. I appoint Messrs. Root, Smith, and Sumner.

I am asked by the secretary to make the announcement that the several committees on award, by referring to the secretary at the conclusion of this session, will be given certain papers that have been submitted in competition.

Shall we continue with other papers—it is now 5 o'clock—or shall we adjourn for this afternoon? If the chair hears no motion to adjourn, he will continue.

Adjournment was taken, with announcement of an informal meeting at the National Geographical Society building at 8 o'clock in the evening.

At 8 o'clock p. m., at the invitation of Mr. Richard E. Follett, vice-president and manager of the New England Forest, Fish, and Game Association, the members proceeded to the hall of the National Geographic Society and witnessed an exhibition of motion pictures of fishing, hunting, and logging scenes, some of which had never before been displayed.

MORNING SESSION, WEDNESDAY, SEPTEMBER 23.

NEW WILLARD HOTEL.

The congress was called to order by the president at 9.45 o'clock.

[After calling for Prof. E. E. Prince and Dr. I. A. Field, who did not respond, the chair recognized Chevalier Guido Rossati, who spoke on "Economic Conditions of the Fisheries in Italy." Mr. Rossati's remarks appear in full on pages 323–332.

Dr. Tasaku Kitahara then read a paper entitled "The Fisheries of Japan, Considered from the Geographical Standpoint." This paper will be found on pages 375–379.]

The PRESIDENT. The paper of Doctor Kitahara is open for discussion. Are there questions to be asked in regard to the fisheries in Japan? Are there experiments that have been made that we can profit by? If the paper is not discussed, I will then ask for the next, a paper by Mr. Charles H. Stevenson; and in introducing Mr. Stevenson I would like to present to the congress a book that has recently appeared, of which Dr. George F. Kunz and Mr. Stevenson are joint authors. This book will be placed on the table here for inspection. It is entitled "The Book of the Pearl," and it is bound in form appropriate to the contents. It is a most beautiful volume.

[Mr. Stevenson dealt with "Preservation of fisheries on the high seas," reading extracts on this subject from his paper on "International Regulations of the Fisheries of the High Seas," which appears in full on pages 103–178.]

The PRESIDENT. The paper that you have listened to is now open to discussion.

[The paper was thereupon discussed by Mr. Olsen and Mr. Fryer, for whose remarks see pages 179 and 180.]

The PRESIDENT. Are there others who will speak on this most interesting topic? I imagine that we have discovered this morning an authority for a forthcoming work on piscicultural jurisprudence. If there are no others to speak on this matter, I will call for another paper that bears upon the subject, by Mr. Dennis.

Mr. OREGON MILTON DENNIS (Baltimore, Maryland). Possibly a word of explanation, Mr. President and ladies and gentlemen, is due at this time, in view of the fact that the paper which I have prepared was intended to be delivered before the American Fisheries Society. When I arrived in Washington yesterday I found that for the time being, at least, the American Fisheries Society had been absorbed by this congress; and I therefore thank you, gentlemen, for this opportunity, in view of those facts.

Another word: The views which I shall express are not those as a representative from my association, nor from my state, nor from the fact that I have been the state warden of Maryland. They are views gathered from experience in filling those various offices. I make that explanation because I want to stand personally responsible.

[Mr. Dennis's paper appears on pages 187–192.]

The PRESIDENT. Are there comments upon this paper? Is Doctor Sumner present? [No response.]

The remaining papers for this morning are papers that will be illustrated by the lantern. Doctor Sumner will deliver the first paper and Mr. Townsend the second paper—the first upon certain biological survey work that is being carried on at the station at Woods Hole under Doctor Sumner's direction, and the second paper, a most interesting one, giving illustrations that were taken in the field by Mr. Townsend, showing the appearance of the seal islands off the Alaskan coast, the behavior of the seals, the methods of capture, and so on. I am sure all members of the congress will wish to stay this morning until 12 o'clock to listen to these two papers. While we are waiting for Doctor Sumner, however, there are certain announcements I have been requested to make.

The chairmen of the respective committees on awards are asked to meet immediately after luncheon to-day at the Arlington at such place as may be indicated by Professor Birge. Professor Birge will be at the Arlington, and will arrange with the various chairmen for a joint session—not any other committees, but the committees on awards. I beg that the chairmen of these committees will confer with Professor Birge during the luncheon hour at the Arlington.

Of course, you understand that members of the International Fishery Congress and ladies are invited to be the guests of the American Fisheries Society at an informal luncheon at the Arlington at 12 o'clock sharp.

I have received a request through room 1001 to the effect that the members and those regularly attending these meetings will please register. It is very important that those who are identifying themselves with this congress should leave their names and addresses; otherwise it is impossible for the local committee to reach you with invitations and with announcements. At the conclusion of this session will you tarry long enough to register at room 1001?

I have also been requested to announce that the only members who are exempt from the payment of dues in this congress are those officially appointed from the foreign governments and the United States Government. A list of these officially appointed members appears on the programme. By some error it was suggested that those connected with the Bureau of Fisheries and not officially appointed by the United States Government were exempt from dues. I am asked to state that those who are employees of the Bureau of Fisheries will have the privilege of paying their dues. [Laughter and applause.]

To regulate the various congresses, of which this is the fourth, it is necessary that an international commission shall be convened. This commission will meet this afternoon at 1.30, after luncheon, in the Arlington Hotel, where the luncheon is served; and Doctor Smith will kindly read the names of those who are members of this international commission that will provide for the next meeting of the congress.

The SECRETARY-GENERAL. I will explain, Mr. President and gentlemen, that this Permanent Commission of the International Fishery Congresses has been appointed for the purpose of looking after the affairs of those congresses in the interim between the regular meetings; and it has as regular members persons selected from countries which have regularly participated in previous International Fishery Congresses. However, owing to the absence of a number of those members, representatives of countries not officially represented here have been invited to act with this permanent commission, and this is the list as decided on: Austria, Dr. Heinrich von Kadich; Brazil, Lieut. Radler de Aquino; Canada, Prof. E. E. Prince; China, Mr. Chang Po Ling; Great Britain, Mr. O. T. Olsen; Germany, Dr. Walther Naumann; Holland, Dr. P. P. C. Hoek; Italy, Dr. D. Vinciguerra and Chevalier Guido Rossati; Japan, Dr. T. Kitahara; Mexico, Mr. José F. Godoy; New Zealand, Mr. H. Stephenson Smith; Peru, Dr. Robert E. Coker; Roumania, Dr. Gregoire Antipa; Sweden, Dr. Oscar Nordqvist; United States of America, Dr. Hermon C. Bumpus, Dr. Richard Rathbun, and Dr. Hugh M. Smith.

The PRESIDENT. I have been requested to suggest that brief abstracts of papers—that is, abstracts that will indicate the contents of the papers—be prepared and handed to Doctor Moore. A great many requests have been received from the press and from individuals asking for the substance of the papers, somewhat more extensive than is given by the title alone. What is requested is a brief statement, in writing, of the substance of the papers that are to be presented, those abstracts to be left, if you please, on the secretary's desk or given directly to Doctor Moore. Is Director Townsend present?

A MEMBER. He is in the audience, Mr. President.

The PRESIDENT. With Doctor Sumner's consent, as it is a little late now, we will call for Doctor Sumner's paper at another session, and ask Director Townsend to present his paper, which is fully illustrated with lantern slides,

and on the conclusion of Director Townsend's paper we will proceed to the Arlington Hotel for luncheon.

Mr. Follett states that in view of there having been a large number of applications, or, perhaps, regrets, on the part of members of this congress that they were not fortunate enough to see the extraordinary exhibition of moving pictures last evening at the Geographical Society building, those pictures will again be put on the screen this afternoon at 5 o'clock at the same place, so that if you or your friends wish to come at 5 o'clock this afternoon you will be quite welcome.

The chair has been asked the duration of the touring trip this afternoon. It will consume practically two hours, the party leaving at 3 and returning about 5 o'clock.

The only other item on the programme this morning is the paper by Director Townsend, and I will ask Mr. Townsend to come to the platform.

Mr. CHARLES H. TOWNSEND (Director New York Aquarium). Mr. President and members of the congress, I shall take up only a few minutes of your time with this old story of the fur-seal fisheries; it is an old story to a great many of the officers of the Bureau of Fisheries in Washington. I suppose I can give you a very condensed account of it in about fifteen minutes, and then it will take about ten or fifteen minutes more to show you a few lantern slides I have brought along.

[For this paper see pages 315–322.]

On the conclusion of Mr. Townsend's paper, at 12 o'clock, the congress adjourned, and the members proceeded to the Arlington Hotel, where a complimentary luncheon was tendered by the American Fisheries Society.

WEDNESDAY AFTERNOON, SEPTEMBER 23.

RECEPTION BY THE PRESIDENT OF THE UNITED STATES, AT THE WHITE HOUSE.

The members of the congress and accompanying ladies assembled at the White House, and at 2.30 o'clock were received by President Roosevelt in the East Room. The President greeted the members as follows:

LADIES AND GENTLEMEN: I shall not try to make you any address, because I am to have the pleasure of shaking hands with each of you. I shall simply say what a pleasure it is to me to greet you here. I have grown to feel more and more that the problem of the conservation of natural resources is the great material problem before modern nations. Savages, barbarians, semicivilized people, and a good many civilized people do nothing but waste natural resources, and it is our business as we become more civilized to try to conserve them. That applies exactly as much to fisheries as it does to forests. One of the problems that will come up in connection with our treaties with foreign nations hereafter must be the arrangement of a method of preserving international fisheries—such fisheries as those in Lake Erie and Puget Sound. It is an outrage

to leave them to be squandered so that our children shall lose all benefit from them, and some method must be devised by international agreement for preserving them.

I am glad to have the opportunity of seeing you.

Each of the members was then presented to President Roosevelt by the secretary-general.

Following the President's reception a group photograph of the delegation was taken on the west portico of the Treasury Department building.

The remainder of the afternoon was spent in an automobile tour of the city for sight-seeing.

At 7.30 o'clock p. m., the members visited the Library of Congress in special cars, and were received by officials of the Library.

MORNING SESSION, THURSDAY, SEPTEMBER 24.

NEW WILLARD HOTEL.

The congress was duly called to order by the president at 9.50 o'clock.

The PRESIDENT. There are here on exhibition a few specimens that were submitted in competition for one of the prizes. These three specimens are submitted by one competitor. Here [indicating] is another specimen that is submitted by another competitor. I hope at your convenience you will examine them.

Are there matters of business to come before the congress? Upon the blackboard are listed the papers that will be presented to-day, and as far as possible they will be called for in that order. Of course, there are some gentlemen who have been unable to get their papers back from the committee on awards. We will now call for the first paper, as announced on the board. Dr. W. W. Yen is to present a paper on "The Fisheries of China." Doctor Yen, will you please come to the platform?

[This paper will be found on pages 367–373.]

The PRESIDENT. I think if we had come here merely to listen to this one paper we would have been repaid. As an indication of the progress in China, not only have we listened to this paper—this astonishing paper—but China has also delegated six persons to attend this congress, four of whom you must have noted are in constant attendance. The discussion of this paper and the presentation of other matter bearing upon the progressive attitude that China is taking in regard to the fisheries will be undertaken by Mr. Chang Po Ling, who is the special commissioner from Tientsin.

[Mr. Chang, however, asked to be excused, as having had little experience in public speaking.]

The PRESIDENT. At this hour, with your permission, I would ask to be relieved of occupying the chair, and will Doctor Hoek kindly take it?

[Whereupon Vice-President P. P. C. Hoek took the chair.]

Dr. HERMON C. BUMPUS. Mr. President, on behalf of Doctor Mead, who has been working for a number of years upon the problems connected with the propagation of the lobster, I would like to present informally to this congress reports upon his work, which are submitted in this substantial manner [showing manuscript and illustrations], and which I trust certain members who are interested in this work will examine.

[Doctor Bumpus then gave an abstract of the two papers by Dr. A. D. Mead, "A Method of Lobster Culture" and "A New Principle of Aquiculture," which are given in full on pages 219–240 and 759–780.]

Vice-President HOEK. Gentlemen, in the absence of Doctor Mead, I think we owe great thanks to Professor Bumpus for the excellent way in which he has given us a summary of these most interesting papers. I may say it, because they belong to a group of papers submitted to a committee of which I have the pleasure and honor to be chairman—the committee on awards. Of course, it would be entirely indiscreet to tell you about the conclusion to which that committee will come; at the same time, I am perfectly at liberty to say that we have at the present moment a very high regard for these excellent papers, not only for the contents but also for the excellent way in which these papers have been prepared, and the most excellent photographs and illustrations which are added to them. So, gentlemen, perhaps it will be of use to have them circulated among you, and, by all means, if the gentlemen wish to review them it will give me great pleasure to hand them over.

Before proceeding, the secretary-general is to give you a short announcement.

The SECRETARY-GENERAL. The office of the congress has received through our State Department communications from practically all of the governments of the earth in regard to their participation in this congress. Among the absentees which we particularly regret is Russia, a country which has such important fisheries and fishery resources. We have received only this morning through our State Department a communication from the American ambassador at St. Petersburg, in which he states that the foreign office has just advised him that they can not be represented at this congress, since they have but two fishery experts, Doctor von Grimm, who is an old man and can not get ready in time, and Mr. Borodine, who has just completed a term in prison for signing the Viborg manifesto, and whom they are unwilling to send on such a mission at this time. [Laughter.]

Vice-President HOEK. We next come, gentlemen, to a paper by Mr. Charles G. Atkins, Superintendent of the Fisheries Station at East Orland, Maine, entitled "Foods for Young Salmonoid Fishes." Is Mr. Atkins present?

Mr. CHARLES G. ATKINS. Mr. President and members of the Fishery Congress, I have a paper here on food for young salmonoid fishes. I much regret that the time at the disposal of the congress does not allow me to read this in full, as in the abstract that I shall give you I shall be obliged to omit a great

many statements that appear to be important and which I think might be interesting to you, but I shall endeavor to give you the gist of it and the most important points.

[Mr. Atkins then presented his paper, which appears on pages 839–851.]

Vice-President HOEK. I now open the discussion on the beautiful lecture we have had from Mr. Atkins. Does anyone wish to ask questions of Mr. Atkins, or to communicate something in relation to the subject? If not, then it only remains as my duty to extend to Mr. Atkins thanks for his excellent paper.

I think we now come to the paper of Mr. L. F. Ayson, of New Zealand, which will be read by Mr. H. Stephenson Smith.

Mr. H. STEPHENSON SMITH (New Zealand). I very much regret that we are unable to hear the gentleman who is the author of this paper, Mr. L. F. Ayson, Superintendent of Fisheries at Wellington, New Zealand. I think a great many of the members know him, and know him to be a very able man. I regret that he is not here to read it.

[Thereupon Mr. Ayson's paper on "The Introduction of American Fishes into New Zealand" was read. This paper is printed on pages 967–973, and is followed by remarks of Mr. H. Stephenson Smith on geographical features of New Zealand.]

Vice-President HOEK. Ladies and gentlemen, you all heard the interesting paper of Mr. Ayson, as it was read by Mr. Smith, and now perhaps Mr. Smith is willing to give further information, if some of the members desire to ask questions.

Mr. SMITH. I will have much pleasure in giving any information I can.

Vice-President HOEK. Should any of you wish to ask Mr. Smith questions regarding this paper of Mr. Ayson, he will gladly respond. You heard from him that it is not his paper, but that of the Superintendent of Fisheries for New Zealand.

[Mr. John W. Titcomb and Prof. Edward E. Prince discussed the paper. See page 974.]

Dr. T. KITAHARA (Japan). The Congress may be interested in the results of the transplanting of American fishes into the waters of Japan. For this we owe much to the kindness of the American authorities. First of all in 1877, 10,000 eggs of the rainbow trout were transported to the Bureau of Agriculture, Tokyo, through the kindness of the fish commissioner of California. It is believed that this was the first transplanting to another country ever tried with that species. About half the number of the eggs sent died on the way, the remainder were taken to Mr. Sekizawa's home, and hatched in the water of the well near his house. The resulting fry were liberated in a small pond in the suburb of Tokyo. As the fish grew larger the pond became too restricted, so the fish were again transferred to another larger pond. In 1879, 20,000 eggs were procured from 5 fish, hatched, and distributed to the lakes at Nikko and Wakamatsu (Aiza). Ten years afterwards

(1887), 4,000 fry of the same species were liberated in the lake at Nikko, and recently, in 1907, 200,000 fry brought from America in the form of eggs were put into the same lake.

Vice-President HOEK. We had better go on at once to the next paper. If I am reliably informed, we shall have considerable discussion on the whitefish production of the Great Lakes. May I ask whether Mr. Frank N. Clark, Superintendent of the Fisheries Station at Northville, Michigan, is present? Will you now give us the pleasure of hearing your paper, sir?

Mr. FRANK N. CLARK. Mr. President, ladies, and gentlemen, having received a communication from the secretary-general of this congress requesting me to prepare something upon a subject which comprises the study and labor of the past forty years of my life, and realizing that the papers which would be submitted at this meeting for your thought and consideration would be innumerable, I have concluded that a mere outline of my plan for the promotion of the whitefish industry of the Great Lakes is the most that would be proper for me to submit to you on this occasion. In preparing the following paper I was not unmindful of the desirability of eliminating, in so far as possible, complicated and tiresome matter.

[Mr. Clark then read his paper, "A Plan for Promoting the Whitefish Production of the Great Lakes," which appears on pages 635–642.]

A MEMBER. There are two more papers on this subject. Each one advocates an open season during the spawning season of the whitefish, and each one proposes remedies very similar to those of Mr. Clark. I therefore move, sir, that before having any discussion on this paper the other papers be read.

[The motion was duly seconded and carried.]

Vice-President HOEK. I have the pleasure now to say that the paper of Mr. S. W. Downing, superintendent of the United States Fisheries Station at Put-in-Bay, Ohio, will be read by Mr. Titcomb.

[Mr. Downing's paper appears on pages 627–633.]

Vice-President HOEK. Professor Ward, will you be so kind as to read for us the paper of Mr. Paul Reighard of the University of Michigan, Ann Arbor, Mich., on this same subject?

Prof. HENRY B. WARD. I have, Mr. President and gentlemen, been requested to read the paper by Mr. Reighard on a plan to promote the whitefish production of the Great Lakes. It is my intention, even at the risk of doing the paper injustice, to present merely a few words of the introduction and the conclusions.

[The paper of Mr. Reighard was then read in abstract, and appears in full on pages 643–684.]

Vice-President HOEK. Gentlemen, we have had three papers on that interesting question, the promotion of the whitefish production of the Great Lakes, and it is understood that the discussion of the question shall take place in the afternoon; and I have now the pleasure of calling on Mr. J. W. Titcomb, the

chief of the division of fish culture, United States Bureau of Fisheries, to give us his lecture on American fish-cultural methods.

A MEMBER. While the lantern is being made ready, I would make the announcement that the chairmen and secretaries of the several committees on award are requested to meet on this side of the room immediately following the lecture.

[The lecture of Mr. Titcomb was then delivered. It will be found on pages 697–757.]

Vice-President HOEK. Three cheers for the Bureau of Fisheries, and our thanks to Mr. Titcomb for his very interesting exhibit and explanation.

Thereupon, at 12.45 p. m., the congress adjourned to meet at 2.30 p. m., and the members were tendered a complimentary luncheon at the New Willard Hotel by the Blue Ridge Rod and Gun Club.

AFTERNOON SESSION, THURSDAY, SEPTEMBER 24.

NEW WILLARD HOTEL.

The congress was called to order by the president at 2.30 o'clock.

The PRESIDENT. The time has come for our afternoon session. I shall first call for the report of the international commission which is in charge of the affairs of the congress. Doctor Smith, secretary-general, will present the report.

Doctor SMITH. Mr. President, ladies, and gentlemen, a meeting of the Permanent Commission of the International Fishery Congresses was held yesterday, the 23d of September. The members of this commission in attendance were Messrs. Bumpus (chairman), von Kadich, Vinciguerra, Rossati, Antipa, Nordqvist, de Aquino, Olsen, Naumann, Godoy, Bengoechea, and H. M. Smith (secretary).

Doctor Vinciguerra presented an invitation from the Italian Fisheries Society to meet in Rome in 1911, on the occasion of the fiftieth anniversary of the Italian Federation. An invitation was likewise received from the mayor of Rome. The commission unanimously accepted the invitation and agreed to report the same to the congress for final ratification.

Dr. Walther Naumann, representing the German Fisheries Society, announced that at the next congress an invitation to meet in Germany would be formally presented.

The proposition of Mr. Nicholas Borodine for an international dictionary of fishing and fish-cultural terms was indorsed, and the secretary was instructed to bring the matter to the attention of the congress, with a favorable recommendation to the committee on resolutions.

After some further business that need not come before the general congress, the commission adjourned.

The PRESIDENT. You have heard the report of the secretary of this commission. A motion to adopt the report is in order.

A MEMBER. I move, sir, that the report be adopted.

The PRESIDENT. The motion has been made favoring the adoption. Is this motion seconded?

[The motion was duly seconded.]

The PRESIDENT. The matter is now open to discussion. Are there those who wish to discuss this report? If not, the motion will be put.

[The motion was duly carried.]

The PRESIDENT. Are there other matters to come before the congress?

Doctor VINCIGUERRA. I am sorry that I can not well explain in English my deep gratification and that of my country in realizing that the congress has agreed to accept the invitation of the Italian Fisheries Society; and I am sure that the members of the congress in Italy will be found in accord in a reception, if not so great as in America, as kind and as friendly as that we have had here. [Applause.]

The PRESIDENT. I am asked to convene the committee on resolutions. The committee on resolutions will meet immediately after this afternoon session, and the members of that committee I shall again announce, so that there may be no misunderstanding. They are Prof. Edward E. Prince, Dr. Tarleton H. Bean, and the secretary-general.

Is there other matter for consideration, Mr. Secretary?

The SECRETARY-GENERAL. The office is in receipt of a cablegram from the Uruguay Lobos Fishing Company, involving a matter which had probably better be referred to the committee on resolutions, but which it might not be out of order to read:

LONDON, *September 24, 1908.*

SECRETARY INTERNATIONAL FISHERY CONGRESS,
Washington.

Considering the terrible slaughter of seals due to poaching, would the congress see their way to include the question of pelagic sealing in their deliberations, as, if seals are not protected by international agreement, the species will disappear within very few years.

URUGUAY LOBOS FISHING COMPANY.

The PRESIDENT. A second communication has been received.

The SECRETARY-GENERAL. This is from Mr. Edward Hatch, jr., and reads as follows:

NEW YORK, *September 23, 1908.*

INTERNATIONAL FISHERY CONGRESS,
Washington, D. C.

Please do not fail in your deliberations to call attention to the great damage done the fish industry by sewage and manufacturing wastes.

EDWARD HATCH, Jr.

The PRESIDENT. What is your wish in regard to these two important communications that have come to us by wire? Ordinarily they would be referred to the committee on resolutions.

[A motion to this effect was made, seconded, and carried.]

The PRESIDENT. Is there anything more, Mr. Secretary? If not, the next item on the programme is the discussion of the whitefish question. I have been informed that this is a rather important matter everywhere; and the chair, in view of the large number who will probably speak upon the question, will apply rather severely the instructions which he has received in regard to the limitation of the time taken by various disputants. We want a large number to speak, but the time is three minutes, unless the chair is otherwise instructed.

It is also suggested that this discussion may be a rather long one, and it might be wise to place a limit upon the total amount of time that we shall give to the first item on the programme. Is anyone prepared to make a motion that the time assigned to this question, namely, the whitefish production of the Great Lakes, shall be limited?

A MEMBER. I move that a limitation of forty minutes be placed on the entire discussion.

The PRESIDENT. The motion is made that the time for the entire discussion be limited to forty minutes. Are there any who approve? Are there any who object to this limitation?

A MEMBER. I hope that this motion will not prevail. It is one of the most important questions to come before this congress, and I think three minutes given each speaker ought to be sufficient limitation without any further restriction.

The PRESIDENT. The chair hears no second to the original motion. If the motion has not been seconded, there is no need of our taking action thereupon. We will proceed to the discussion of the whitefish question.

[The subject was discussed at length by Prof. Edward E. Prince, Mr. C. H. Wilson, Hon. Paul North, Mr. A. Kelly Evans, Dr. Barton W. Evermann, Dr. Tarleton H. Bean, Mr. Charles E. Fryer, Mr. Frank N. Clark, Mr. John W. Titcomb, Mr. William E. Meehan, Mr. Seymour Bower, Prof. E. A. Birge, Mr. W. T. Thompson, Mr. J. J. Stranahan, Mr. Samuel F. Fullerton, and Mr. Dwight Lydell. The remarks of these members will be found in the order given, the discussion beginning on page 685.]

The PRESIDENT. Are there others who wish to contribute? If not, the discussion will be closed. Unless there is objection to closing, we shall call for the paper by Dr. P. P. C. Hoek, upon the Rhine salmon. [Applause.] Professor Prince, will you kindly take the chair as vice-president? [Applause.]

[Thereupon Prof. Edward E. Prince took the chair.

Doctor Hoek then read his paper entitled, "Propagation and Protection of the Rhine Salmon," which appears on pages 817–829.]

Vice-President PRINCE. I am sure you will bear out the policy of the chair in not rigidly limiting Doctor Hoek, but giving him as much time as we could reasonably allow, because this paper, like every memoir with which

Doctor Hoek has favored the piscicultural world, is so full of real worth that it would have been a pity to omit any part of it.

I have no doubt there are some present who have some questions to ask. Now will be the opportunity for any comments or questions, but I must warn the congress that the observations must be very brief.

[The paper was briefly discussed by Prof. E. E. Prince and Doctor Hoek, whose remarks appear on page 829.]

Vice-President PRINCE. Gentlemen, as the time is passing rapidly and there seem to be no questions on this paper of Doctor Hoek, although we appreciate it very much as a valuable paper and record of personal observations, we shall proceed to the next, by Mr. W. S. Kincaid, who is to read a paper on "New Methods of Transporting Eggs and Fish." Is Mr. Kincaid present? [No response.] In the absence of Mr. Kincaid, we shall have to proceed to the next paper. The secretary-general will read a paper by Professor Matsubara.

The SECRETARY-GENERAL. Mr. President and gentlemen, this paper by Prof. S. Matsubara, on "Goldfish and Their Culture in Japan," is of great interest to many people, but I do not know that we have the time or opportunity to read it in extenso. I should certainly like to call attention to the contents of the paper and exhibit some of the admirable colored paintings which accompany it. Professor Matsubara is the Director of the Imperial Fisheries Institute at Tokyo, Japan, and, as we know, the goldfish receives more attention in Japan than in any other country.

[The paper was then read in abstract, and will be found in full on pages 381–397.

President Bumpus at this point resumed the chair.]

The PRESIDENT. This paper is open for discussion. We have an interesting paper by Professor Prince on the "Training and Qualifications of the Modern Fish Culturist."

I am sure no one has been more surprised than I, during this afternoon's session in particular, at the amount of accurate information that seems to be on hand among the men who are connected with the various fish hatcheries of the country. I wonder where it is possible to find such men. I sat here wondering that the United States Government can succeed in getting these perfectly splendid men—men who are specialists, that do this work so well and know it in all its branches and ramifications. Now, I imagine, although I have not seen the paper that is about to be presented, that there is a plan for the direct training of such individuals.

Prof. EDWARD E. PRINCE. Mr. President and gentlemen, I fully agree with the words which you have just expressed in regard to the gentlemen who have appeared before us to-day, who are the practical fish culturists. What I have to bring before you will occupy only five or six minutes, because I

intend merely giving the main points of my paper, which is rather in the way of suggestion than of a set treatise or essay.

[This paper was then read in abstract.]

The PRESIDENT. Members of the congress, this interesting paper is open for discussion. I think that we all feel that the ground has been pretty well covered by Professor Prince. The fact that the paper is not being discussed does not indicate that we have not been very much interested in and instructed by listening to it.

May I ask if the secretary-general has the paper by Mr. Franz von Pirko, "The Naturalization of American Fishes in Austrian Waters?"

The SECRETARY-GENERAL. Mr. von Pirko has been obliged to leave the city, and I shall not read his paper, but shall simply state that he has gone to the trouble to write it in excellent English and to give us for distribution copies of it printed in German. These will be distributed to those who desire them, and the paper will simply be read by title and published in full in the proceedings. [See pages 977–982.]

The PRESIDENT. I am instructed to state that all of the papers that have been submitted to the conference and reports of the discussions taken by the stenographer will be published by the United States Government and distributed.

We now come to the last subject on the programme for this afternoon, the dogfish question, to be opened by Professor Field, and to be discussed by Messrs. Fryer, Nordqvist, Gill, Whitman, Prince, and others.

Prof. IRVING A. FIELD. Mr. President and gentlemen, I am asked to start the discussion this afternoon on the dogfish question. Before entering on that, I wish to say a few words on the mussel. The title of the paper which was called for yesterday and the day before is, "Sea Mussels and Dogfish as Food." I have here a few samples of preserved mussels and dogfish, which I shall pass around.

[Professor Field's paper appears on pages 241–248, and following it is the discussion, which was participated in by the president, Dr. Oscar Nordqvist, Dr. Theodore Gill, Mr. Charles E. Fryer, Mr. T. E. Libby, Mr. Charles G. Atkins, Mr. John J. Pew, Prof. E. E. Prince, Dr. George W. Field, Mr. Walter E. Hathaway, Mr. E. C. Whitman, and Prof. Irving A. Field.]

The PRESIDENT. If there are no more contributors to this discussion, a motion to adjourn will be put.

The SECRETARY-GENERAL. Before the motion is put, I would like to suggest that, in view of the lateness of the hour, the committee on resolutions do not meet this evening, but instead at 9 o'clock to-morrow forenoon, in this room.

Thereupon, at 6 o'clock p. m., the congress adjourned until 9.30 o'clock Friday morning.

MORNING SESSION, FRIDAY, SEPTEMBER 25.

NEW WILLARD HOTEL.

The congress was duly convened by the president at 9.45 o'clock.

The PRESIDENT. We will now begin our work. Are there any matters to be presented by the secretary?

The SECRETARY-GENERAL. Mr. President and gentlemen, many messages of good will and greeting have come to the congress from persons who are prevented from being with us. The cable message from the distinguished president of the Third International Fishery Congress has already been read. Among the other messages received have been the following:

Mr. Nicholas Borodine, Secretary-General of the Second International Fishery Congress and late Chief Specialist in Fish Culture in the Russian Department of Agriculture, asks that his best wishes be given to the members of the congress, and to those members who remember him he sends his special regards and his assurance that though unavoidably absent he is with them in spirit.

Dr. David Starr Jordan, United States International Fishery Commissioner, writes:

> Will you kindly present my compliments to the Fishery Congress and express to them my interest in their work? It is a matter of sincere regret to me that I can not be present at this auspicious meeting. The affairs of the university, combined with the work of the International Commission of Fisheries, occupy all my available time, and I must forego the honor and the pleasure of being associated with this convention.

Mr. H. Wheeler Perce, president of the National Association of Scientific Angling Clubs, has written a very interesting letter, which will be published among the papers of the congress. [See pages 193–198.]

Greetings have come from—

Dr. E. L. Mark, of the Zoological Laboratory of Harvard University, at Cambridge, Mass., and Director of the Biological Station at Hamilton, Bermuda.

Prof. Dr. Bruno Hofer, of the Royal Bavarian Research Station for Fisheries, Munich, Germany.

Dr. Ernst Ehrenbaum, of the Royal Biological Experiment Station at Helgoland, Germany.

Dr. H. Henking, of the German Fishery Society, Berlin, Germany.

Prof. Jules Cotte, of the Marine Zoological Station of the University of Marseille, France.

I would also like to bring to the attention of the congress at this time some recently published or manuscript works which have been presented by their respective authors for the information of the congress.

[The secretary-general read a list of the works that had been submitted, which list, with later additions, appears on page 74.]

The PRESIDENT. Mr. Fullerton has just spoken to me about a matter of general misunderstanding in regard to the whitefish question, and it seems to

me to be of sufficient importance to be brought again before the attention of the congress. I will ask him kindly to make that statement made to me a moment ago.

[Mr. Fullerton's statement appears on page 695.]

The PRESIDENT. Unless there is some other business to be transacted before we proceed to the reading of the papers, the chair will now call for the papers as listed on the blackboard.

Doctor Meek, will you give the initial paper this morning?

Dr. S. E. MEEK (Field Museum, Chicago). I have some lantern slides.

The PRESIDENT. Is the operator not here? Then, in view of Doctor Smith's return, I will ask the secretary-general to present the paper of Mr. N. Borodine.

The SECRETARY-GENERAL. It will probably be desirable, Mr. President, to refer this communication to the committee on resolutions. Mr. Borodine writes as follows:

PROPOSAL FOR AN INTERNATIONAL CONDENSED DICTIONARY OF THE TERMINI TECHNICI USED IN THE FISHERIES AND FISH CULTURE.

One of the most important tasks of the International Fishery Congress is to make as easy as possible the study of the state of the fisheries and fish culture in all countries and to unite efforts of the specialists for the advancement of applied science concerning fishery matters and of the fishery industries themselves. A great obstacle to this, however, as to all other branches of science, is the difference of the languages in which the works on ichthyology, fish culture, and the fisheries are printed, and in the difficulty, well known to every body of colleagues, when they try to understand even only the most important points, such as conclusions, statistical tables, explanation of figures, etc., of a work written in an unfamiliar language. It is impossible to overcome this difficulty with an ordinary dictionary, because termini technici are not to be found there, and they are often very different even in the same language.

Having had, in the character of editor of the Revue Internationale de Pêche et de la Pisciculture, much to do with the periodicals and books on fisheries and fish culture written in all European languages, I know very well, by my own experience, how difficult it is, for instance, to make any use of the works written in Danish, Dutch, Hungarian, and other seldom-learned languages. Though the Latin saves us the difficulty, so far as concerns the names of fishes, it can not help us to understand all the other things in the book, sometimes the most interesting. Therefore I have always thought it would be very useful if the specialists of all countries would draw up a kind of little information book or dictionary in which should be found (1) names of all commercial fishes and other fishes and animals that are of some interest to the fishing industries, to sportsmen, and in fish culture; (2) denominations of the most important fishing appliances used by professional fishermen and sportsmen; (3) denominations of fishery vessels, boats, and the principal vessel implements; (4) denominations of the principal fishery products; (5) measures, weights, utensils, etc., used in fishery business, also the different moneys; (6) list of the principal termini technici used in fish culture. All of these denominations ought to be given in the following languages: French, English, German, Italian, Spanish, Norwegian, Swedish, Dutch, Russian (with Latin and Russian letters), Hungarian, Roumanian, and Japanese (with Latin and Japanese letters). Moreover, names of fishes should also be given, it should be understood, in Latin.

To accomplish such a work is not possible but in a collective way, with collaboration of the specialists of each country upon the six categories mentioned above. Naturally the book should first of all be written, as full as possible, in one of the languages, and then

the proper parallel termini technici should be given in other languages, and the list should be completed by adding the new ones, which may not exist at all in other languages, simply because there are no such objects. To avoid misunderstanding, it is to be desired that the original list of termini technici should be accompanied by some explanation of the kind used in the condensed dictionaries (Larausse, Webster, and others). The original list should be reproduced in several copies for distribution among the specialists of all countries where the above-mentioned languages are in use, and every specialist, or many of them, should give a parallel list of the names and of the termini technici used in fisheries in his own country. It is necessary, further, that all these papers should be under direction of one and the same hand in order to give them one system and similar editorial lines. In such a state the work may then be presented to the next congress, by which it should be, if found good, approved, such approbation by the congress being desired in order to fix the terminology, to unify it, and thus to facilitate the use of different books and papers in future.

Such is a general plan for drawing up an international book of information, or dictionary of fisheries and fish culture. I should say in addition that the charge of writing the original list we should beg our German colleagues to take on themselves, for these reasons: First of all, the German terminology in fisheries and fish culture is more elaborated and detailed; besides which, in the German "Handbuch der Fischzucht und Fischerei," by Professors Benecke, Dallmer, and M. von dem Borne, we find already the primitiæ of what should be included in the proposed dictionary.

There is another question: What institution, or what persons, should be engaged to see that the work is completed at the proper time? It would be natural to give this in charge to the "Conseil permanent de la pêche," an executive organ of the International Fishery Congresses. But this institution, as is well known, gives no sign of existence. Or, it would be possible to give this task to the organizing committee of the next congress. But experience shows us that this committee can scarcely accomplish such a task, because it as a rule is not itself organized until a short time before the opening of the congress and has too much work to do at that time. It remains to propose that this work be intrusted to another permanent institution having direct relations with the fisheries, it being better, of course, if such institution be of international character. The only institution of this kind, so far as I know, is the "Conseil international (and bureau of it) pour l'exploration des mers du Nord." If the honorable and highly esteemed secretary of that institution and the members thereof assisting in this congress find my proposal practicable and will be kind enough to render their assistance in the matter, it will be certain that the work will be done.

It will be understood that if my proposal is accepted this congress shall appoint persons from each country to write the respective parts of the whole work. As to the printing of the book, it would be more practicable for each country to have a separate edition, because the alphabets naturally should be the national ones. Then the question of expense for the printing, etc., would be each country's own business.

I have, then, the honor to submit to the Fourth International Fishery Congress at Washington the following proposal for a resolution:

1. That it be recognized as desirable and useful to draw up an international dictionary on fisheries and fish culture in twelve languages, according to the plan outlined above.

2. That the writing of the original text of this dictionary (in German) be intrusted to ....., and the writing of the parallel texts in other languages, or the responsibility therefor, be given to .....

3. That the relations with collaborators for the compiling of this information book be intrusted to the bureau of the "Conseil international pour l'exploration des mers du Nord," which institution will have the right to fix the time for delivering the papers by collaborators in each country, and will provide for unity of form for the whole, bearing in mind, however, that the manuscript of the book, quite ready for printing, shall be presented to the next congress for approval.

The PRESIDENT. Ordinarily communications of this kind, that involve recommendation for indorsement, are referred to the committee on resolutions. The paper, however, may be discussed, if you wish, or the chair will entertain a motion to refer to the committee on resolutions.

Lieutenant DE AQUINO (Brazil). I think we should put in the Portuguese language, which I believe is being spoken by more than 30,000,000 people, and therefore ought not to be left out, although putting in another language would raise the number to thirteen, which may not prove very lucky. I would like to present the suggestion that to the twelve languages be added the Portuguese language.

The PRESIDENT. Will it serve the purpose if the secretary-general of the congress is instructed to so communicate with the editor of the dictionary?

Lieutenant DE AQUINO. Yes, sir.

The PRESIDENT. That will be sufficient?

Lieutenant DE AQUINO. Yes, sir.

Mr. O. T. OLSEN. This subject is a matter to which I have given a great deal of thought and at which I am working. The unification of fish names, I think, is a very desirable thing, and we ought to have done it at this congress. To do it here is impossible, for when we disperse to-morrow what work we have done is finished, and there is nobody to carry it on for the next three years.

I may say with regard to the different languages suggested for the dictionary, to my way of thinking it would not be desirable to have all those languages in one book, inasmuch as if I read the book in English, the Spanish or the Japanese language is no use to me, and there would be so many sections of the book simply lying dead, not being used. Now, I have a different scheme, and that is to have one book in one language, say in English, and when compiled to have it translated into the different languages. I would have a number for each sentence or for each subject, which could be referred to; this number should correspond in all the languages, so that if, we may say, a Russian wishes to get the same meaning in Russian as in English he would simply have communicated to him the number and the reference number, and then he can read in his own language. Then there would be no necessity of having so much matter within the covers of the book used. That is one thing.

The next, Mr. President, is that I am at present compiling a work for the fishermen—that is, the deep-sea fishermen. The subjects to be treated are navigation, the rule of the road, oceanography, fish culture at sea, a little natural history, just sufficient for the fishermen in their calling; and there will also be a chapter on steam, sufficient for them in case of breakdown to repair their engines and get to port, and a few matters like this which I have compiled and I am compiling. And I should be very glad if anyone present who hears me and who feels inclined would supply me, for insertion in that book, any kind

of information respecting any of those subjects that I have mentioned. This book is called for. It has been called for for several years. I have issued two editions of The Fishermen's Practical Navigator, of which this will be the third, brought up to date; and it includes steam fishing vessels, with all the modern improvements and gear. I should be very pleased to hear from anyone who is for progress in the same direction.

The PRESIDENT. A motion to refer to the committee on resolutions is in order, unless there is further discussion.

[The motion was made and duly seconded.]

The PRESIDENT. The motion has been made and seconded, and if there are no objections the chair will so refer.

The paper by Mr. William P. Seal, namely, "Fishes in their Relation to the Mosquito Problem," is a paper that the chair has received several requests for, and if Mr. Seal is here, or if there is some one here who will present the paper for him, that paper will be the one now called for on the programme. [After a pause.] Mr. Seal is in attendance, I am informed, but he seems to be out at the present moment. [For this paper see pages 831–838.]

Then the paper by Professor Wilson, which is "On the Development of Sponges from Tissue Cells Outside the Body of the Parent," will be called for, and I shall ask Doctor Moore if he will kindly introduce the discussion on this paper when the reading is finished.

[Prof. H. V. Wilson presented his paper, which appears on pages 1265–1271.]

The PRESIDENT. Are you willing to leave these specimens on the table, Professor Wilson, for a little opportunity to examine them? Perhaps Professor Wilson will be willing to meet you at the close of this session for a few moments, and explain the preparations to those who care for a special explanation.

Doctor Moore has asked me to state that he has a number of things to attend to just now, and that he would prefer not to undertake to discuss the paper of Professor Wilson. Nevertheless, he would like me to state that in the basement of the building of the Bureau of Fisheries there is an exhibit that shows the process of budding and growth of commercial sponges. You will find an exhibit made there which represents the work that the United States Bureau of Fisheries has done during the experiments for some years past in this most important matter.

Are there other questions to be asked of Professor Wilson from the floor? If not, I shall ask Doctor Evermann to present in abstract the paper, "Experiments in the Artificial Propagation of Freshwater Mussels," by Prof. George Lefevre and Prof. W. C. Curtis.

Dr. B. W. EVERMANN (U. S. Bureau of Fisheries). Mr. President and gentlemen, I regret very much that neither Doctor Lefevre nor Professor Curtis has found it possible to be present at this congress. We all felt, however, that something should be said regarding certain experiments which they have been carrying on. I shall not present the formal paper which they prepared, but

shall give you a more or less rambling talk concerning some of the questions, at least, which are dealt with in their formal paper.

[The paper by Professors Lefevre and Curtis will be found on pages 615–626.]

Mr. PAUL NORTH (Ohio). Will you kindly explain in reference to the colored buttons?

The PRESIDENT. Mr. North asks a question. I learn that those which are discolored—are not uniform in color—are smoked by putting into nitrate of silver, and made into what is called the "smoky pearl." There is a small demand for buttons of other colors, and those are produced by using aniline dyes, by which they can be made red, blue, and the different colors obtainable in the aniline dyes.

The members may have noted the various exhibits that have been brought to the congress, with certain papers submitted in competition for prizes, and material that has been presented here by those who have been good enough to contribute to the programme. This material has been arranged in front of the desk, and those who are interested in discussing it will kindly come to the desk at the conclusion of the sessions. And I shall ask those who have contributed the material to please install themselves as demonstrators of the respective exhibits.

Will the honorable Mexican minister, Mr. José F. Godoy, please come to the platform? [Applause.]

Mr. GODOY. Mr. President and members of the Fourth International Fishery Congress, it is with great pleasure that I address you these few words to inform you that the Government I have the honor to represent here has felt great interest in, and attaches great importance to, the meeting of this congress. The discussions held at these sessions and the conclusions to be determined upon will no doubt greatly aid the Mexican Government in framing ampler regulations on the subject of fisheries, and I hope will also serve to establish measures looking to the preservation and increase of our fish industry.

Permit me, in the name of President Porfirio Diaz, whose progressive and enlightened administration of affairs is well known to most of you, to present you his greetings and his best wishes for the success of your important labors. Permit me also to inform you that the Department of Promotion, which has the subject of fisheries under its charge in my country, and which at present is directed by Minister Olegario Molina, a most active and efficient cabinet officer, is looking to the results of the labors of this congress as a guide for its future work along the lines that may be pointed out in the deliberations of this international gathering.

To me, who have had the privilege of residing some time in Washington, the cordiality shown in the reception accorded to the members of this congress here has not been surprising. We all know the well-earned reputation for courtesy and hospitality which the inhabitants of Washington enjoy, and therefore it was

to be expected that the welcome extended in this city to the members of this congress would be, as it has been, most warm and cordial.

The well-chosen words with which the Acting Secretary of State, Mr. Adee, received the delegates, and the timely and thoughtful address of the Secretary of Commerce and Labor, as well as the hearty manner in which Commissioner West extended the city's welcome, were but a forerunner of the enthusiastic way in which this congress was to be treated. No less hearty was the reception accorded to its members by His Excellency President Roosevelt, the honored head of this nation, whose warm hand grasp and frank and eloquent utterances were indicative that he was in hearty approval of the labors of this congress. These indications, as well as the interest shown in the work of this convention by the enlightened press of this city, and the facilities and advantages afforded by the well-established libraries and museums of Washington, no doubt have contributed to spur on the investigation and resolution of the subjects here for discussion.

And let me not forget, among the advantages enjoyed by us, the timely election made of our president and secretary. I know full well that Mr. Bumpus and Mr. Smith are not fishing for compliments, but I can assure you that we gathered in our nets the best president and secretary that we could have selected.

Under such auspicious circumstances the work of this congress has gone on, and when such work shall be finished I think that all of you will say with me that we are proud to be members of the Fourth International Fishery Congress, and to have contributed, even if it is but by our close attention and hearty applause, to the far-reaching and important labors of those who organized this gathering and carried it on to a successful conclusion.

Thanking all of you for your kind attention, as also for the undeserved honor of having been selected as one of your vice-presidents, I again convey to you Mexico's greetings and good wishes.

The PRESIDENT. Secretary-General Smith has a communication from Ecuador.

The SECRETARY-GENERAL. I have had placed in my hand by Señor Don Esteban F. Carbo, who represents the Republic of Ecuador, a communication, which, with your permission, I will read:

HONORABLE DELEGATES: As delegate for Ecuador to the International Fisheries Congress, I have the honor to call your illustrious attention toward a new and hitherto unknown field of activity for the interesting, valuable, and productive industry of fisheries. I speak with reference to Ecuadorian waters, and especially of the Colon Archipelago (Galapagos Islands), which belongs to the Republic of Ecuador and is situated about 500 nautical miles from the coast of said country, and enjoys the old and well merited reputation for its magnificent geographical position, its splendid climate, smooth seas which surround it, and for the abundant and choice resources in turtles, grouper (known by the native name of mero), and infinite and rich varieties of other fish. The Government of Ecuador is ready to extend all facilities and its decided support to the enterprise or enterprises which will propose to dedicate themselves to the fisheries of the

archipelago, which could be converted into one of the most productive industries in the world.

The location of the islands of the Colon Archipelago, as I expressed before, could not be more advantageous to the fishing industry, on account of the facilities to ship their products to all markets. The opening of the Panama Canal will augment those facilities, providing at the same time the advantage of maritime commerce, because a large number of vessels will stop on their voyages to and from North America, South America, and Australia.

The circumstance that the ocean which surrounds these islands is tranquil all the year round, hurricanes and fogs being unknown, and the undisputed mildness of one of the best climates known give to the islands of the archipelago of Colon an exceptional opportunity for establishing important fisheries with indubitable benefit for the persons who will undertake it and for the whole world which will enjoy the excellence of those products. Well-known travelers have made careful studies of the Colon Archipelago and they are all consistent with the datum that I submit to the congress.

Small colonies can be established because the soil is rich, the ports are good, there is abundance of wild cattle, and the villages that will be erected by those interested in fishing may become important cities, there being all the facilities for living. Salt mines may be worked on the islands to salt the fish, and the nearby coast of Ecuador has numerous mines that are now in operation.

With the few undetailed facts that I give, gentlemen, I am sure that you will be convinced that the fishing industry has a new horizon and that the Archipelago of Colon is destined to be one of the most important centers of universal activity in such an important branch of the industries.

The eminent Dr. Teodoro Wolf in his "Geology and Geography of Ecuador" says:

"The islands of Galapagos lie 9°, or from 500 to 600 nautical miles, from the Ecuadorian coast and are traversed by the equinoctial line. The principal mass of the islands, including the 5 largest ones—that is to say, Albemarle, Indefatigable, Narborough, James, and Chatham—lies between said line and the first austral degree; only the 3 small ones—Abingdon, Bindloe, and Towers—are north of the line, and 2 not much larger—Charles (Floreana) and Hood—south of the first austral degree. There are commonly 13 islands, adding to the ones I have mentioned those of Barrington, Duncan, and Jervis. Furthermore, there are several smaller keys which surround the large islands. The longitudinal area of the archipelago, from Chatham to Narborough, measures 53 leagues, and the latitudinal from Floreana to Abingdon, 41 leagues, in a manner such that these islands are found scattered over an area on the Pacific Ocean of 2,000 square leagues, nevertheless reunited in one body they would have an area of 240 square leagues of solid ground. Albemarle, the largest, has 138 square leagues. In the inland region of the islands the ground is covered with a turf that is green the year round. The thickets offer a large variety of trees and shrubs of equal magnificence and verdure."

Doctor Wolf, in speaking of the colonization of the islands, calls attention to the fact that the fishing along the coast of the islands could be elevated to a plane of great importance, which would be a fountain of richness to the colonizers and which would give occupation to a numerous population. There would be in addition numerous subordinate industries, such as the taking of the oil from turtles and terrestrial iguanas.

On the question of harbors and anchorage, Lieut. Commander Z. L. Tanner, U. S. Navy, commanding the United States Fish Commission's steamer *Albatross*, says: "There are no landlocked harbors in the Galapagos, but anchorages are found near most of the islands, where a vessel may lie usually with perfect safety. Indefatigable Island affords good anchorages from Conway Bay along its northern side to the Seymour Islands; there are places also along the northeast side where good protection may be found. Chatham Island has several good anchorages. Wreck Bay is the most important, as it is the seaport of the Hacienda del Progreso, a large sugar plantation. It is open to the westward, but particularly protected by Schiavoni reef; there is usually a small swell, but

landing or lightering is seldom interrupted. Stevens Bay is superior as a harbor, has more room, and has a snug cove which forms an excellent boat landing and harbor for small craft or lighters, its smooth beach affording excellent opportunity for hauling them out for repairs. Post-Office Bay, 4 miles to the north of Black Beach Road, is one of the best anchorages in the Archipelago. It is well protected, with moderate depth of water and good holding ground. Landing is practicable at all times." There are many other anchorages on these islands too numerous to be mentioned in this brief report.

Commander Tanner, commenting on the strategical value of the archipelago, goes on to say: "The strategical value of the islands is increasing with the advent of modern cruisers which are entirely dependent upon steam as a motive power. They are in direct route from San Francisco to Callao and Valparaiso, and, in the event of the completion of the Panama Canal, they would lie in the route to Australia and New Zealand and would become a regular port of call for steamers plying between those places. A glance at the map will show the location of the group with reference to the coasts of North, Central, and South America, and the value of a coaling station at that point, nearly midway between San Francisco and Lota, the southernmost coaling port in the Pacific, becomes at once apparent. A modern cruiser could make the run direct from San Francisco to the Galapagos, fill up with coal, procure fresh provisions from shore, and reach the South American coast with a good supply of fuel, avoiding the longer and more expensive route via Acapulco and Panama. The location of the islands in the region of the southeast trade winds is particularly favorable for the delivery of coal from Australia, Lota, or even from the Atlantic coast. It could be laid down there at much less cost than at Acapulco or Panama."

I ask, therefore, of the honorable delegates of the different countries here represented that they be so kind as to call the attention of their countrymen toward the fisheries of the Archipelago of Colon (Islands of Galapagos) in the certainty that they will reap great rewards.

The PRESIDENT. Professor Vinciguerra has a communication to present to the congress.

Prof. DECIO VINCIGUERRA. Before this congress adjourns I think it proper to call its attention to a subject which was discussed at the International Fishery Congresses of St. Petersburg and Vienna, namely, the timeliness of an international oceanographic exploration of the Mediterranean Sea in the interest of fisheries. The same question was debated at various international geographic congresses, and recently at the Geographic Congress of Geneva. I had the honor to report on this subject on behalf of the Italian Geographical Society. The importance of this proposition was recognized by the Geneva Congress, which has intrusted its consideration to a committee, whose presidency has been offered to the Prince of Monaco, whose valuable contributions to oceanography are well known. On this committee should be represented all nations of the Mediterranean shore, the Adriatic and Black seas included. I think it superfluous to tell this congress the reasons why the fishery interests of the Mediterranean make this exploration impellent, because it is generally known that whatever legislation there may be on the matter, and especially that having an international character, can be based only upon the knowledge of the life history of fishes and on that of the physical conditions of the waters where they live. I confine myself, therefore, to the proposition that this congress, reaffirming its former votes, shall approve the proposed exploration.

The PRESIDENT. You have heard this most interesting communication that brings to us business that was begun three years ago. What is your pleasure in regard to the communication that has been thus submitted?

A MEMBER. It is a matter of very great importance, and I move you, sir, that the communication be referred to the committee on resolutions.

The PRESIDENT. Is the motion seconded?

[The motion was duly seconded.]

The PRESIDENT. The motion has been made and seconded. The matter is now open to discussion, if you care for discussion. If the chair hears no request, then——

Mr. CHARLES E. FRYER. I would like to ask Professor Vinciguerra whether it is proposed that the explorations of the Mediterranean in regard to the interests of the fisheries should be limited to the powers which adjoin the Mediterranean, or whether other countries would participate. I raise the question for the reason that quite recently some English fishing vessels have actually been fishing in the Mediterranean, having been tempted to try their fortune on the eastern side of the Straits of Gibraltar, and if such practices were to extend it would undoubtedly enlarge the sphere of inquiry in which any such committee as is proposed would be concerned. All the powers that are likely to take up fishing operations in the Mediterranean should, it seems to me, have a share in such a scheme of investigations as is proposed.

Another point to which I should like to call attention would be the great desirability of especially directing any investigation to those problems which immediately affect the interests of the fisheries. This is a fishery congress, and although we all fully recognize that fisheries involve questions of interest in many different sciences, still our chief interest is that of fisheries, and I would suggest that, just as in the case of the North Sea investigations, the international council for which is now sitting in Copenhagen, the first and immediate points for consideration should be those which affect the future industrial welfare of fishermen and fisheries.

The PRESIDENT. The stenographer has taken down the remarks of Mr. Fryer, and these remarks will become a part of the published reports of this congress. If there is definite action on the part of the congress required by Mr. Fryer, the chair will be very glad to entertain any motion to that effect; and will Professor Vinciguerra kindly reply to the queries that were put to him?

Professor VINCIGUERRA. It is the intention of the committee which was proposed to invite all nations that have interests on the Mediterranean to take a part in these explorations, and three or four members have already been indicated, because their countries were well represented at the Geneva congress. All the other nations, not only of the Mediterranean, but also in the Adriatic and Black seas, will have a representative—Roumania, Russia, and also Germany, because Germany has a station on the Adriatic Sea; and the representative of Germany at the congress in Geneva made the proposition that also Germany

must have a member in this committee. And I suppose, for instance, England has great interests in the Mediterranean, and without doubt England will be entitled to take a part in this enterprise.

Our thought is to promote the exploration of the Mediterranean in the interest of the fisheries. Then it is clear that the fisheries interests may be the main influence that may be regarded in these explorations.

I hope that Mr. Fryer now fully understands.

[The motion before the congress was carried, and the communication of Professor Vinciguerra was referred to the committee on resolutions.]

The PRESIDENT. I have been requested to read the following communication from those who have in charge the luncheon that is to be served to-day by the Alaskan Packers' Association, as a compliment to the congress. [Communication read.]

Now, one other matter: There are still some who, because of their interest in the programme as rendered in this room, have forgotten to register, and you are again asked to kindly register and become organically connected with the congress.

Then there are some who have signified their intention, by handing in their names, to attend the subscription banquet this evening, and who have not yet received the cards of admission. It would be too bad if any member of the congress should come to the Hotel Raleigh this evening, after having prepared himself for the banquet, and find that although he had on a "wedding garment," nevertheless "he could not enter in." [Laughter.]

Is there other incidental matter to come up before we proceed with the reading of papers? There are a few of these [indicating] badges here for those members who care for them.

Doctor Field, will you kindly give an abstract—the substance—of the paper submitted by H. C. Rowe? Mr. H. C. Rowe is at the head of one of the largest oyster concerns in America, and he entertains the members of the congress on our arrival in Fall River on Tuesday morning next. One of Mr. Rowe's steamers (he has a large fleet of these steamers, of course) will meet us there at 8 o'clock on Tuesday morning and will take us to one of the large oyster beds, and that steamer will then show the method of steam dredging and oyster culture that is carried on in Narragansett Bay, a method which is used throughout Long Island Sound and in the extensive beds still farther south. Doctor Field is quite well acquainted with this work in Narragansett Bay. The paper is rather long, and Doctor Field will give it to us in abstract.

Dr. GEORGE W. FIELD. We must all regret the absence of Mr. Rowe, who would be able to present this to you in a better shape than I can.

[The paper by Mr. H. C. Rowe was then presented in abstract; the full paper appears on pages 259-267.]

The PRESIDENT. There is some probability that the various committees on award will be prepared to make their reports in time to be read at the conclusion

of the luncheon this noon. We hope that these committees' announcements may be made at that time—at the conclusion of the luncheon in the banquet hall.

The next paper is one that has been prepared by Professor Reighard, and Doctor Ward has consented to give it to us in abstract. Is Doctor Ward here? If Doctor Ward is not here, I shall ask for the paper by Mr. Seal. Is Mr. Seal here? [No response. This paper is printed on pages 831–838.]

[At this point Professor Vinciguerra was invited to the chair.]

Vice-President VINCIGUERRA. We will, then, now hear the paper by Dr. S. E. Meek, of the Field Museum of Natural History, Chicago, entitled "A Study of Lakes Amatitlan and Atitlan, Guatemala, with Especial Reference to Fish Culture."

[Dr. Meek's paper was then read.]

Vice-President VINCIGUERRA. I now have pleasure in introducing Hon. Gifford Pinchot, Chief Forester of the United States Department of Agriculture. [Applause.]

Mr. GIFFORD PINCHOT. Mr. President, ladies, and gentlemen, it is a real pleasure for me to foregather with a body of people interested in fishing. I should like to assure you that the old proverbial question, "What would you rather do or go fishing" has but one answer with me: I would always rather fish; and I have accumulated in the course of my life a certain number of fish stories, which I shall not inflict upon you here. I know that this is an economic congress, and in what I have to say I want mainly to take the economic point of view.

The Forest Service is fortunate in having a very direct relation to the fisheries question. It has charge of the area which includes the headwaters of the streams which water about two-thirds of the United States; and through the 2,500 or 2,600 men who compose its force the opportunity is afforded of helping in the preservation of food and game fishes, an opportunity, I should like to add, its officers very greatly prize.

You are well aware that questions of game and fish are reserved to the states, and national officers have little to do with them, outside the national game reserves and national parks, except as they may be also state officers. A majority of the rangers in the national forests have in fact become state officers, for the purpose of protecting the fish and game, and we are doing what we can to enforce state laws and prevent the indiscriminate slaughter of both fish and game; and, I think I may venture to say, with some success.

I suppose there are few questions which more completely show the interrelation of the different natural resources of a country than does the fisheries question; and that in its relation not to the forests, but to other resources as well. I suppose the majority of the types of fresh-water fish depend directly on the conservation of the forests, if not for the very existence of the species, at least for its plentiful distribution. That is why the Forest Service has so direct a relation to the fisheries question; and in various parts of the country,

especially in the national forests in the West, at least a good beginning has been made to protect the streams upon which fresh-water game fish depend.

But it is not by any means enough to protect the forests; other things must come in also. Where we have protected the headwaters of a stream with forest cover and are maintaining it, even then there are very serious dangers connected with other uses of the land and water which appeal directly, as I should imagine, to a congress such as this. For example, where water is used for power a great many fish may be killed by the physical arrangement of the apparatus. In the same manner, enormous numbers of game fish perish from time to time because of the use of the water in which they live for irrigation, and the lack of a proper system of protective headgates to keep the fish from getting into the irrigation ditches.

I believe that few things will have a more beneficial influence, in the end, on the fisheries of the country than the demand for clear water in our streams for city and town supply. The fishery question is thus immediately connected with one of the great fundamental problems of conservation in the United States, which is to prevent soil wash and so to maintain the fertility of the soil on the farms.

As an illustration of the unity of this great conservation problem, which has taken so firm a hold on the people of the United States since it was first propounded by the President, I think the fisheries question is one of the best.

It is a little difficult to connect sea fisheries with forest preservation, and yet even in places that connection exists. The condition of the harbors and the lower salt reaches of the great rivers is directly affected by the condition of the forest cover at the head waters; and thus even here, while the relation is by no means so direct, it still exists.

Therefore—and this is the substance of what I wanted to say to you to-day—it seems to me that every single one of the interests that are concerned with any phase of this great conservation problem is also concerned with the rest of it. You are intimately concerned with forests, water power, irrigation, soil conservation, and a number of others. All of these interests in their turn are concerned with the preservation and protection of the food and game fish.

Many of us have been seeking for definite results on definite lines, with a good deal of lack of success, and for a good many years we have been working too much alone. If the great question of conservation is a single question, then it seems to me the natural remedy in this age of combination lies in the combination of the interests of all of us who need to get the same things done.

I have been asking and getting for the National Conservation Commission the heartiest and most vigorous support and cooperation for the one central object of conservation on the part of a very large number of associations that are interested in specific and individual parts of the great whole. Your help is greatly needed. You are concerned with the business and common-sense use of foresight in providing for things which you foresee the need of, as well

as in preventing or repairing losses which may happen or have happened. The same spirit of looking ahead, the use of the same kind of prudence and good sense that a man employs in dealing with his own business affairs, is the key to the solution of your problem. So it is of the forest problem, the water-power problem, the soil-erosion problem, the navigation problem, which affects, of course, your work most intimately; and all the other great individual problems concerned in this greatest of all movements.

So I have wanted to bespeak for the conservation movement the sympathy and good will of the fisheries men just exactly as the fisheries men should have and do have the sympathy and good will and cooperation of the forest men; and I should be very glad indeed if in any way whatever the Forest Service can more efficiently promote the work you have in hand. I should welcome any assistance or advice you may be willing to give for that purpose.

Thank you very much for your attention.

Mr. S. G. WORTH (Superintendent U. S. Fisheries Station, Edenton, North Carolina). I have listened attentively to the papers and discussions in the sessions of this congress, and there is nothing I have heard in these meetings that has interested me more, or that has seemed to be a broader-gauged question, than the one alluded to by the last speaker. I have been in fish-cultural work for something like thirty-one years, and acquainted with the Piedmont section of North Carolina during that time. It has been painful to me for many years to see the ruin that has taken place in the streams of that section; and when I recently rode through the State from Cape Lookout to Asheville, it occurred to me that I ought then to sit down and write a newspaper article, encouraging the people connected with the state government to take some steps against the washing away of the lands. This last speaker has asked for some suggestion by which the Forest Service could aid us, and I may make this suggestion to him, that in Wake County, N. C., which is the site of the state capitol, there is a species of hillside ditching carried on by the cotton and corn farmers of that country which obviates almost entirely the washing away of those lands. It is a perfected system, which has been in existence there for years. I lived for a year on the farm of the late Jesse F. Taylor, where I saw that great land improvement which he had effected, and where he had stopped all the land wash; and I became acquainted with the principles of that hillside ditching; and I recommend to the Forest Service the study and extension of the system of hillside ditching referred to, as a universal benefit to fish culture in the United States. I would close my remarks by saying that it is one of the simplest and cheapest operations that I have ever seen, and may be done entirely with a 1-horse turn plow and a long-handled shovel.

The PRESIDENT. Are there others who will make suggestions or remarks? If not, the session will adjourn until 2.30 this afternoon.

Thereupon, at 12.30 p. m., the congress adjourned.

At 1 o'clock the members of the congress were tendered a complimentary salmon luncheon by the Alaska Packers' Association in the banquet hall of the New Willard Hotel. Mr. C. W. Dorr, vice-president of the association, presided at this function, and remarks were made by Commissioner George M. Bowers, Hon. John M. Allen, Hon. William R. Wheeler, Mr. Charles E. Fryer, Mr. H. C. Bliss, Mr. John H. Wallace, jr., Prof. Edward E. Prince, and Dr. P. P. C. Hoek. At the conclusion of the luncheon Prof. E. A. Birge submitted the report of the committee on competitive awards (for which see page 69).

AFTERNOON SESSION, FRIDAY, SEPTEMBER 25.

NEW WILLARD HOTEL.

The congress was called to order by the president at 3.15 o'clock.

The PRESIDENT. Will the committee on resolutions kindly submit resolutions for the general adoption of the congress? We shall now listen to the illustrated paper by Prof. E. A. Birge on "The Gases Dissolved in the Waters of Wisconsin Lakes."

[Professor Birge's paper, followed by discussion by Mr. J. J. Stranahan, Dr. Oscar Nordqvist, and Professor Birge, appears on pages 1273–1294.]

Mr. M. G. SELLERS (Pennsylvania). Mr. President and gentlemen of the congress, it is not my purpose to in any way discuss the scientific feature of Professor Birge's paper, but its presentation brings up a very serious question, which I thought it might be advisable to express to you to-day. I appear before you only in the character of an angler. It is the function of the fish commissions to populate inland lakes of the various states. Inland lakes, I take it, concern the angler more than they do the commercial fisherman.

Has it ever occurred to you that outside of a philanthropic effort on the part of the owners of the land bordering such lakes, the general public have to either pay toll or request the privilege of going in and angling for what the state has planted in those waters? I consider that this is a question largely concerning the anglers; but, nevertheless, it has a great deal to do with the question of food and angling, in so far as it represents the great bulk of the money distributed through a state by the sportsmen who seek that kind of pleasure. In my own State of Pennsylvania we have not solved that problem. I know of no state yet, in the whole United States or in foreign countries, which has solved satisfactorily the problem of providing means of ingress and egress for the angling public to inland lakes, for the great privilege of enjoying fishing. I had intended to bring this subject before you in the shape of a paper, because I think it is a burning subject, in that when the state through its departments of a public nature propagates fish, to plant them in the waters of the inland lakes, as I have described, the general public should, I feel, have some means of ingress and egress that they may partake of what the state has done primarily for their benefit.

I do not feel that I ought to take up more time in discussing a problem on which I might tire you, but it is a very serious question not only to the State of Pennsylvania, as I say, but to all states—the free right of trespass to partake of what is hatched in the hatcheries for the benefit of the general public of the several states.

Mr. JOHN J. PEW (Massachusetts). Mr. Chairman, in our state you can not exclude the public from fishing in a pond of, I think, 10 acres.

Mr. SELLERS. It is 20 acres.

Mr. PEW. In New Hampshire, I think, a man owned a lake and tried to keep the public out of it. The inhabitants were very angry, and they went through the fields and entered that lake; and they carried the matter to the superior court, which decided that by that law the inhabitants had the right to fish in that lake, and it could not be shut up to the people—that was either in Maine or New Hampshire.

Mr. SELLERS. I would suggest that in Pennsylvania, as an angler, my first duty, about twenty years ago, was to bring about a free right for the public to fish streams in which brook trout were planted by the state. Those streams in their original nature were created navigable by acts of the assembly, and the right of fishing was never mentioned in those acts, which start away back in 1814 and continue up to the year 1870. After many years of hard effort, I finally succeeded, in 1901, in the State of Pennsylvania, in getting through the legislature a bill which accorded to the general public the right to fish those navigable streams.

It may be of great interest to you to know why this is a burning question to the State of Pennsylvania. I shall describe a case that has been decided against the Commonwealth, in so far as it refers to the public fishing in those waters. We have always assumed—in fact, case after case, not getting further than the local magistrate, has been decided always in favor of the angler. Usually when a stream is well stocked by the state and the fishing becomes good in our thickly populated eastern sections, it is a misfortune that about the first thing to happen is that someone, or a combination of persons having good success, think it a very wise thing to lease the water and have it all to themselves. That occurs frequently, with the result that one stream in particular, in a section of Pennsylvania, which was declared navigable by act of assembly in the year 1814, was subjected to a test. An angler went into that creek. In order to insure that he would not trespass on the riparian right of the owner, he walked down the country road and got into the creek from the bridge, and was careful to keep in that creek to the point of the highway mark. He was arrested, brought before the magistrate, and was fined for trespass. Representing the Pennsylvania Fish Protective Association, we appealed that case and took it to the superior court; and without taking any more of your time on a question which is not quite scientific, we were absolutely beaten, because the constitution of Pennsylvania

is declared to be greater than the acts of the legislature, in that there was no compensation given to the owner of the land, hence he had a free right to the positive control of that creek, not only along its highway, but along the bed of the creek.

Gentlemen, I can not begin to tell you what I feel for the angler of Pennsylvania. I fear that public trout fishing in the State of Pennsylvania will some day become a very, very expensive luxury, due to the fact that at the present time, unless we go to the Supreme Court of the United States, we do not know what that decision might be. We do not know whether we have any public fishing waters for trout in the State of Pennsylvania; and my heart goes out to the anglers who formerly fished those waters and who may in the future find it very expensive to get a little trout fishing.

Dr. TARLETON H. BEAN (New York). I do not know whether I exactly understood the gentleman in his remarks about the State of Pennsylvania in regard to providing for the public fishing, but I ought to say that in New York, which appropriates, I think, about as much money for fish culture as any other State of the Union, no streams except public streams are provided with fish. It is not possible for a private owner to secure fish from the state; and when a stream has been stocked with fish by the state it becomes public water. There were 2,000 streams stocked during the last year with brook trout alone, and every one of those streams becomes a stream open to the public for fishing.

Mr. A. KELLY EVANS (Canada). As some reference has been made to the State of Maine, and I do not know that the state representative is here, I might point out that in that state, which undoubtedly has proved the most successful in turning angling and sport into an asset of great wealth to the state, amounting last year undoubtedly, from its statistics, to twenty-five millions of money brought into the state, its system provided this: That in any lake called a big pond, of a greater area than 10 acres, anyone can go and fish, even if an individual owns the land completely surrounding it, unless that land is cultivated. If it is not cultivated and is, comparatively speaking, wild land, the only action the owner can take is to bring the man who comes in and fishes on the lake before the courts; and the owner must prove damage in his passing through that land; but he has no right to prevent that man from fishing in that lake. And so universal has that custom become in the State of Maine that no attempt is made by private owners to control either lakes or streams. Where this works out to the advantage of the state and to the fish culturist is this, that the sympathy of the public is entirely with the fish culturist and with the whole system, in so far as no private ownership is allowed. I may say, Mr. Chairman, that it has been because of the wonderful success of Maine—the money that Maine has shown to exist in this system—that I myself have been successful in arousing an agitation in the Province of Ontario, and on account of always speaking and voting for holding the waters open to the public I have thereby received the

sympathy and support of the general public. And we find in Canada this, gentlemen, and I shall only take one moment to tell you so, that the greatest difficulty in the world exists in protecting the rights to the salmon river owners, because when we attempt to carry out the laws of the country as to the placing and lifting of nets and so on in the mouths of the rivers, we feel that after all the public is against those actions by the state, on account of the streams being owned by private individuals. And I take it that on a broad principle, as far as game fishes go, it is undoubtedly best for the whole body politic, for the fish culturist, and for everybody concerned to keep the waters absolutely open to the public.

The PRESIDENT. This has been a congress of young men. There is one young man here who is twice the age of some of us in years, but who has been identified with the subject of practical fish culture in America from its inception. He has been a friend of every ichthyologist and every ichthyologist in America has to-day a feeling of intense devotion for him. The chair therefore feels that the concluding session of this congress should properly be turned over to Dr. Theodore N. Gill. [Great applause.]

Dr. THEODORE N. GILL (Washington, D. C., assuming the chair). Mr. President and gentlemen, in order to insure conciseness and to avoid digressiveness, I have put my thoughts in writing, and without further preface I will read a paper I have prepared embodying "A Plea for Observation of the habits of fishes and Against Undue Generalization."

[This paper, with discussion by Prof. E. E. Prince, Dr. Tarleton H. Bean, Dr. Hugh M. Smith, and the author, will be found on pages 1059–1069.]

The ACTING CHAIRMAN. If there is no further discussion, the report of the committee on resolutions is now in order. Professor Prince is the chairman of that committee. Will Professor Prince give us the report?

Professor PRINCE. It is unnecessary to say anything about the work of this committee. I shall just read the resolutions; that is all that is necessary. The first resolution we had before us and which we now present to the congress is one which would express the views of the congress upon three important matters, and I shall just read word for word the resolutions, as we present them. I presume it is not necessary to have separate action on each resolution.

The ACTING CHAIRMAN. The chair presumes that it is not necessary to act upon each of these resolutions separately. If there is no objection we shall consider them all together and act upon them at the end.

Professor PRINCE. I shall proceed to read them all, Mr. Chairman.

[The resolutions were here read. See page 67.]

The ACTING CHAIRMAN. You have heard the resolutions with respect to the different matters. Have you anything to say? Have you any motion to make or any further remarks? The resolutions as you have heard, gentlemen, are before you now for ratification. All in favor of these various resolutions will

please signify by the usual manner, "Aye;" all opposed, "No." No objection being offered, the resolutions that you have heard have all been accepted.

Professor PRINCE. I should say that there is still one addendum, and that is in regard to the international condensed dictionary of technical terms, which Mr. Borodine, of Russia, has proposed. The congress has had this matter before it, and I need not read the somewhat lengthy resolutions which Doctor Borodine suggested to the congress, but the committee on resolutions were disposed to favor this proposal; and perhaps, Mr. Chairman, it might still be left to the congress to decide what to do with it.

The ACTING CHAIRMAN. You have heard the proposition of the gentleman, and the question is what shall be done with this—that is, whether, for example, it should be referred to the permanent commission or whether it should be acted upon immediately. A motion to that end is now in order. What is your pleasure, gentlemen?

Doctor HOEK. I suggest the wisdom of laying the resolution in the hands of the permanent commission and not undertaking to reach a decision on it at present.

[The motion was duly seconded.]

The ACTING CHAIRMAN. You have heard the motion by Doctor Hoek. It is proposed that this resolution should be referred to the permanent commission and that no action be taken by the congress for the present. All in favor of this motion will please signify by the affirmative sign; all opposed, "No." It is carried, and the resolution is so referred.

It is suggested by the secretary that Professor Ward will present the paper by Professor Reighard, for which a prize has been awarded.

Professor PRINCE. One moment. There is another resolution.

The ACTING CHAIRMAN. Doctor Prince will offer another resolution.

Professor PRINCE. Doctor Vinciguerra has just brought before the congress a resolution which had been referred to the committee—a resolution on the matter which was discussed at the international fishery congresses at St. Petersburg and Vienna, namely, an international commission on oceanography and exploration of the Mediterranean in the interest of fisheries. The scope of the resolution has been given by Doctor Vinciguerra, and the committee are favorable to that resolution.

The ACTING CHAIRMAN. If there is no demand for the reading of this resolution, it will be considered as it has been enunciated. There apparently being no demand, the question is before the congress. All in favor of adopting this resolution will please signify in the affirmative; all opposed, "No." It is carried. We shall now proceed to the regular business.

Prof. HENRY B. WARD. I find myself in the agreeable position of being called upon to read a paper by my friend and colleague, Doctor Reighard. It would seem like cruelty to fishermen, if not to other animals, to inflict on you a long

paper; consequently, although this is one that has been awarded a prize by the committee on awards, I shall take the liberty of cutting it in such fashion as to present the essential features and leave out the other matter which is not necessary to your comprehension at the present moment. I consequently pass over the introduction, which deals with the work of all previous investigators, including our chairman, Doctor Gill, and shall proceed at once to the second section of the paper, the general principles involved in the field study of fishes. Possibly I neglected to mention the exact title, "Methods of Studying the Habits and Recording the Life Histories of Fishes."

[This paper, read in abstract, is printed in full on pages 1111–1136.]

The ACTING CHAIRMAN. The chair thanks Doctor Ward for the distinct and excellent rendition that he has made of Doctor Reighard's paper. The donor of the prize, assuming that the entire memoir is of the same character as the part read, thinks that the award was amply justified, and is very much gratified that such an excellent paper has been produced. In respect to the species whose life history has been recorded it would, however, be well, I think, if Professor Reighard would add that the same characteristics of nest building are manifest in the other species of the genus *Semotilus;* that is, in *Semotilus bullaris*. It has been denied that *Semotilus bullaris* exercised this function of parental supervision. Doctor Abbott many years ago denied it in the most explicit manner, but recently a member of the Bureau of Fisheries, Doctor Kendall, has observed the habits, and has well illustrated it in a recent report published by the Bureau of Fisheries, giving the details of his work in New Hampshire and Maine.

The chair congratulates the congress upon the happy results of its meeting here, upon the excellent papers that have been presented, the harmonious relations that have been established; and the meeting will now stand adjourned sine die.

Thereupon, at 5.50 o'clock p. m., the congress took final adjournment.

During the week following the adjournment of the congress a party of foreign and local delegates visited points of special interest in New York and New England in accordance with a prearranged programme.

On September 28 Mr. Charles H. Townsend, director of the New York Aquarium, tendered a reception followed by a private view of the aquarium; Prof. H. Fairfield Osborn, president of the American Museum of Natural History, gave a reception and luncheon at the museum.

The party was met at Fall River, Mass., on September 29 by Mr. Henry C. Rowe, president of the Connecticut Oyster Growers' Association, and taken in a steam oyster vessel to his private oyster grounds in Narragansett Bay, where there was given a demonstration of oyster dredging, gathering of starfish from

the oyster beds, etc. The delegates then proceeded to Wickford, R. I., and were received by the governor of Rhode Island and the members of the Rhode Island Commission of Inland Fisheries on the latter's houseboat *Biophore*, where luncheon was served. The inspection of the lobster-rearing plant of the Rhode Island Commission, the main object of the visit, followed, after which the party proceeded to Newport for the night.

On September 30 the United States fisheries steamer *Fish Hawk* took the delegates from Newport to Woods Hole, Mass., where the government marine fish hatchery and laboratory were inspected.

In Boston on October 1 the delegates were the guests of the T Wharf Association and the Boston Fish Bureau, being escorted in automobiles to the fish wharves, fish-packing establishments, Quincy Market cold storage plant, and other points of interest. Hon. Curtis Guild, governor of Massachusetts, received and addressed the delegates at the statehouse. A complimentary luncheon was tendered by the fish merchants of Boston, and the delegates were there welcomed by the mayor of the city. At Harvard University President Eliot gave an informal reception and address, and the Museum of Comparative Zoology and other buildings were visited. In the evening the party were the guests of honor at a banquet provided by the fishery interests of Boston.

October 2 and 3 were spent in Gloucester, Mass., where a committee of the board of trade and the Master Mariners' Association escorted the visitors to the fish wharves, fish-curing and fish-packing plants, and fish-glue works, and the marine hatchery of the United States Bureau of Fisheries in Gloucester Harbor was inspected. The excursion terminated with a cruise on a mackerel schooner and a demonstration of purse-seine fishing, the boats being manned and the seine operated by the masters of mackerel vessels.

VIEWS AND RESOLUTIONS ADOPTED BY THE CONGRESS.

GENERAL VIEWS.

1. The congress learns with pleasure that the long standing fishery dispute between Great Britain and the United States affecting waters on the northeast coast of North America is likely to be submitted to settlement by arbitration at an early date.

2. We heartily commend the stand of the President of the United States in behalf of the conservation of natural resources, and congratulate him on the beneficial effects of his example and influence at home and abroad.

3. The congress advocates the establishment, in all countries having important fisheries, of national schools of fisheries and fish culture under government auspices.

4. The congress strongly urges the necessity of simplifying fishery laws by the elimination of qualifying clauses which so often provide loopholes through which offenders escape penalties and waters continue without protection.

5. In view of the injury to the fishing communities and the menace to the prosperity of important fishing industries on the Atlantic coast of the United States and Canada arising from the depredations of dogfish, especially of the spiny and smooth dogfishes, this congress favors uniform measures for the extermination or utilization of these injurious fishes in the contiguous waters referred to.

VIEWS OF UNITED STATES DELEGATES.

1. The condition at this time of the shad fishery in east coast streams forbodes ill for its future and demand energetic action on the part of the United States and Canadian provinces. We urge prompt action, especially with regard to interstate waters, that will so regulate fishing as definitely to insure the passage of a fair proportion of the run to the spawning grounds each season. A 10 per cent reduction in the catch at this time may prevent the ultimate destruction of a fishery worth $1,500,000 yearly.

2. We heartily indorse the movement instituted by President Roosevelt for the conservation of our natural resources, and we pledge our official and personal support to measures for insuring the protection of our fishes and other aquatic creatures.

3. Believing that the welfare of all of our most valuable river fisheries demands the preservation of natural conditions at the headwaters of streams, we favor and urge the formation of the Appalachian Forest Reserve and other similar reserves which embrace the watersheds of important streams.

4. The convention between Great Britain and the United States under which the regulation and administration of the fisheries of the boundary waters of the United States and Canada will be undertaken by the respective federal governments marks an epoch in the history of our fisheries. We pledge our support to all measures that, after proper investigation, are found to be necessary for the preservation of the fisheries of the waters in question.

RESOLUTIONS.

1. That the thanks of the congress are due and are hereby tendered to the President of the United States, the Secretary of Commerce and Labor, and the authorities and citizens of the city of Washington for their cordial and effective support.

2. That the thanks of the congress are offered to the Italian Fisheries Society for its cordial invitation to hold the next session in Rome in 1911.

3. That the congress reaffirms the action of previous International Fishery Congresses in recommending an international exploration of the Mediterranean Sea in the interests of the fisheries.

4. That the congress records its sincere appreciation of the inestimable services of Dr. H. C. Bumpus as president and of Dr. Hugh M. Smith as secretary general of the congress, their untiring devotion and constant courtesy as principal officers of the congress having contributed so much to its success.

5. That thanks are freely extended to the following institutions for their generous entertainment and their contributions to the exhibits: The American Fisheries Society, the Blue Ridge Rod and Gun Club, the Alaska Packers' Association, the New England Forest, Fish, and Game Association, the National Geographic Society, the United States National Museum, and the United States Bureau of Fisheries.

6. That the thanks of the congress be, and are hereby, extended to the donors of the various competitive awards.

7. That the efficient and painstaking work of the international committee of awards merits special recognition, and is heartily appreciated by the congress.

8. That the proceedings of the congress be edited and published by the secretary general, who is authorized to incorporate in the volume of proceedings such papers as may have been received but which for lack of time or other reason may not have been formally brought before the congress.

9. That the secretary general be, and he is hereby, authorized and requested to bring the various views and resolutions adopted by the congress to the attention of all persons concerned or interested therein.

COMPETITIVE AWARDS.

In connection with the Fourth International Fishery Congress, arrangements were made for the award of money prizes for the best or most important investigations, discoveries, inventions, etc., relative to fisheries, aquiculture, ichthyology, fish pathology, and related subjects during the years 1906, 1907, and 1908. It was felt by the local management that, while the amounts of the individual prizes were not large, the conferring of the awards by so representative a body as the International Fishery Congress would induce many persons to compete and would result in much benefit to the fisheries and fish culture. In June, 1906, circulars announcing the subjects and conditions of the competition were issued in the English, French, and German languages and were extensively distributed. Several other circulars relating to the matter were sent out in 1907 and 1908.

LIST OF AWARDS.

1. By the AMERICAN FISHERIES SOCIETY: For a paper embodying the most important original observations and investigations regarding the cause, treatment, and prevention of a disease affecting a species of fish under cultivation, $100.

2. By the AMERICAN MUSEUM OF NATURAL HISTORY, New York City: For an original paper describing and illustrating by specimens the best method of preparing fishes for museum and exhibition purposes, $100.

3. By "FOREST AND STREAM," New York City (Mr. George Bird Grinnell, editor): For the best paper giving description, history, and methods of administration of a water, or waters, stocked and preserved as a commercial enterprise, in which angling is open to the public on payment of a fee, $50.

4. By the MUSEUM OF THE BROOKLYN INSTITUTE OF ARTS AND SCIENCES, Brooklyn, N. Y. (Mr. F. A. Lucas, curator in chief): For the best paper setting forth a plan for an educational exhibit of fishes, the species and specimens that should be shown, the method of arrangement, and suggestions for making such an exhibit instructive and attractive, $100.

5. By the NEW YORK AQUARIUM, under the management of the New York Zoological Society, New York City (Mr. Charles H. Townsend, director): For an exposition of the best methods of combating fungus disease in fishes in captivity, $150.

6. By the NEW YORK BOTANICAL GARDEN, New York City (Dr. N. L. Britton, director): For the best essay on any interrelation between marine plants and animals, $100.

7. By the SMITHSONIAN INSTITUTION, Washington, D. C.: For the best essay or treatise on "International regulations of the fisheries on the high seas, their history, objects, and results," $200.

8. By THE FISHERIES COMPANY, Philadelphia, Pa. (Mr. Joseph Wharton, president): For the best essay treating of the effects of fishing on the abundance and movements of surface-swimming fishes which go in schools, particularly the menhaden

and similar species, and the influence of such fishing on the fishes which may prey on such species, $250.

9. By the UNITED STATES BUREAU OF FISHERIES, Washington, D. C.: For a report describing the most useful, new, and original principle, method, or apparatus to be employed in fish culture or in transporting live fishes (competition not open to employees of the Bureau), $200.

10. By the WOLVERINE FISH COMPANY, Detroit, Mich.: For the best plan to promote the whitefish production of the Great Lakes, $100.

11. By MR. HAYES BIGELOW, Brattleboro, Vt., member of the American Fisheries Society: For the best demonstration, based on original investigations and experiments, of the commercial possibilities of growing sponges from eggs or cuttings, $100.

12. By HON. GEORGE M. BOWERS, United States Commissioner of Fisheries, Washington, D. C.: For the best demonstration of the efficacy of artificial propagation as applied to marine fishes, $100.

13. By DR. H. C. BUMPUS, director of the American Museum of Natural History, New York City: For an original and practical method of lobster culture, $100.

14. By MR. JOHN K. CHEYNEY, Tarpon Springs, Fla., member of the American Fisheries Society: For the best presentation treating of the methods of the world's sponge fisheries, the influence of such methods on the supply of sponges, and the most effective means of conserving the sponges.

15. By PROF. THEODORE GILL, honorary associate in zoology, Smithsonian Institution, Washington, D. C.: For the best methods of observing the habits and recording the life histories of fishes, with an illustrative example, $100.

16. By DR. F. M. JOHNSON, Boston, Mass., member of the American Fisheries Society: For the best demonstration of the comparative value of different kinds of foods for use in rearing young salmonoids, taking into consideration cheapness, availability, and potentiality, $150.

17. By the NEW YORK ACADEMY OF SCIENCES, New York City (Dr. N. L. Britton, president): For the contribution, not entered in competition for any other award, which shall be judged to have the greatest practical value to the fisheries or fish culture.

18. By MESSRS. HENRY HOLT & CO., publishers, New York City: For the best series of photographs, with brief descriptions, illustrating the capture of food or game fishes, $100.

CONDITIONS GOVERNING COMPETITION.

1. Any person, association, or company may compete for any of the awards.

2. Each competitor shall, before July 15, 1908, notify the secretary-general of the congress as to the particular award for which he competes; and he shall duly qualify himself as a member of the congress.

3. Each paper or exhibit offered in competition shall be in the custody of the secretary-general on the day of opening of the congress.

4. Papers may be written in English, French, German, or Italian.

5. Each device, apparatus, process, or method for which an award is asked shall be represented by a sample, a model, or an illustrated description; and each shall be accompanied by a complete statement of the points for which an award is asked.

6. The congress reserves the right to publish, prior to their publication elsewhere, any papers or photographs submitted in competition, whether or not such papers or photographs receive awards: *Provided, however*, That in the event of the congress having failed to publish within six months after the session, an author will be at liberty to publish when and where he may elect.

7. The papers, appliances, exhibits, etc., submitted in competition for awards will be examined by an international committee to be designated by the president of the International Fishery Congress.

8. The committee will determine the competitors who are entitled to awards, and the decisions of the committee will be final.

9. The committee may call before it, in order to obtain additional information when desirable, persons who may have entered the competition and also other persons.

10. The committee may, at its discretion, withhold the award in any case if in its judgment no sufficiently worthy competition is presented; and it may divide an award if there are two competitions that it deems of equal merit.

11. The committee will make its report to the congress not later than the day preceding final adjournment.

12. The awards will be announced at a session of the congress, and each award will be accompanied by a special certificate or diploma suitably inscribed and bearing the signatures of the officers of the congress.

INTERNATIONAL COMMITTEE ON AWARDS.

At the opening session of the congress, the president appointed an international committee on awards, consisting of eighteen members who were not competitors. The committee, divided into five subcommittees to deal with the various groups of awards, consisted of the following, of whom Dr. E. A. Birge was chosen as general chairman:

For prizes numbered 3, 7, and 8—Dr. Oscar Nordqvist, chairman; Dr. Theo. S. Palmer, Maj. Richard Sylvester, Dr. Barton W. Evermann, Dr. W. S. Harban.

For prizes numbered 1, 5, 6, 11, 14, and 15—Dr. Decio Vinciguerra, chairman; Dr. E. A. Birge, Dr. F. B. Sumner, Dr. T. Kitahara.

For prize numbered 17—Dr. H. von Kadich, chairman; Dr. Henry B. Ward, Dr. Robert E. Coker.

For prizes numbered 9, 10, 12, 13, and 16—Dr. P. C. C. Hoek, chairman, Mr. W. E. Meehan, Mr. J. W. Titcomb.

For prizes numbered 2, 4, and 18—Dr. Gregoire Antipa, chairman; Dr. S. E. Meek, Dr. F. W. True.

THE AWARDS CONFERRED.

About 50 papers and exhibits were submitted in competition, many of which were of high value and embodied the results of painstaking research and experiment. The committee adopted the following rules for their guidance:

1. No prize shall be awarded except for a paper of exceptional value. Such paper should contain the results of an unusually thorough and complete investigation, or should announce an important new discovery or method.

2. It is not expedient to award less than a full prize to a single paper, although, following the general rules, a prize may be divided between papers of equal merit.

3. In case no award of a prize be given, the committee recommend that the donor be requested to allow the prize to remain open for competition at the next International Fishery Congress.

The committee reported their findings on September 25, and unanimously made the following awards:

No. 2: To Mr. Dwight Franklin, New York City.

No. 4: To Mr. Frederic A. Lucas, Museum of the Brooklyn Institute of Arts and Sciences, New York City, and Mr. Roy W. Miner, American Museum of Natural History, New York City (division of prize).

No. 7: To Mr. Charles H. Stevenson, U. S. Bureau of Fisheries, Washington, D. C.

No. 9: To Dr. A. D. Mead, Brown University, Providence, R. I.

No. 10: To Mr. Paul Reighard, University of Michigan, Ann Arbor, Mich.

No. 11: To Dr. Henry F. Moore, U. S. Bureau of Fisheries, Washington, D. C.

No. 13: To Dr. A. D. Mead, Brown University, Providence, R. I.

No. 14: To Dr. Henry F. Moore, U. S. Bureau of Fisheries, Washington, D. C.

No. 15: To Prof. Jacob Reighard, University of Michigan, Ann Arbor, Mich.
No. 16: To Mr. Charles G. Atkins, U. S. Fisheries Station, Craig Brook, Me.
No. 17: To Mr. John I. Solomon, New York City.

The committee recommended that no awards be made in the case of prizes numbered 1, 3, 5, 6, 8, 12, and 18. For one of these there was no competition and for the others the papers or exhibits were regarded either as not of sufficient merit or as not strictly within the terms of the award.

In recognition of his papers on the sponge fisheries, and his most praiseworthy efforts on behalf of the sponge fishermen, Mr. Charles Flegel, member of the Imperial Austrian Fishery Society, was awarded a special cash prize of $50 by the officers of the congress.

PERMANENT COMMISSION OF THE INTERNATIONAL FISHERY CONGRESSES.

A meeting of the Permanent Commission of the International Fishery Congresses was held at Washington, D. C., on September 23, 1908, in connection with the Fourth International Fishery Congress. The meeting was called to order by the ex-officio chairman, Dr. Hermon C. Bumpus, president of the congress; and the following members were in attendance: Dr. Heinrich von Kadich, representing Austria; Prof. Decio Vinciguerra, representing Italy; Prof. Gregoire Antipa, representing Roumania; Dr. Oscar Fritiof Nordqvist, representing Sweden; Dr. Hugh M. Smith, representing the United States of America.

With the approval of the meeting, the representatives from various other countries were invited to be present, and the following were in attendance: Lieut. Radler de Aquino, representing Brazil; Mr. O. T. Olsen, representing Great Britain; Dr. Walther Naumann, representing Germany; Dr. Ramon Bengoechea, representing Guatemala; Chevalier Guido Rossati, representing Italy; Hon. José F. Godoy, representing Mexico.

Prof. Decio Vinciguerra presented a letter from the president of the Italian Fishery Society, extending on behalf of the society a very cordial invitation to hold the next congress at Rome in 1911, on the occasion of the fiftieth anniversary of Italian unity. An invitation having the same purport was likewise received from the mayor of Rome. After Professor Vinciguerra had seconded the invitation, the commission voted unanimously to accept it, and agreed to report their action to the congress for ratification.

Dr. Walther Naumann announced that at the next congress an invitation to hold the Sixth Congress in Germany would be formally presented.

A proposition from Mr. Nicholas Borodine, of Russia, for an international dictionary of fishing and fish-cultural terms in twelve languages was indorsed, and the secretary was directed to bring the matter to the attention of the congress with a favorable recommendation to the committee on resolutions.

Professor Vinciguerra proposed that at the next congress a scheme should be submitted for imposing more important duties and responsibilities on the Permanent Commission of International Fishery Congresses than have heretofore been assumed. On motion, duly seconded, a committee of three was appointed to consider this matter and report at the next congress, the committee consisting of Professor Vinciguerra (chairman), Dr. P. P. C. Hoek, of Holland, and Prof. Bruno Hofer, of Germany.

The meeting then adjourned.

HUGH M. SMITH, *Secretary.*

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INTERNATIONAL REGULATIONS OF THE FISHERIES ON THE HIGH SEAS

By O. T. Olsen, D. Sc., F. L. S.

WITH DISCUSSION

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

INTERNATIONAL REGULATIONS OF THE FISHERIES ON THE HIGH SEAS.

By O. T. OLSEN, D. Sc., F. L. S.

To attempt a history of the fisheries on the high seas would be like attempting to bail out the ocean or to name all the inhabitants in the vast deep. It is well known to all here that there are no greater flow and ebb in any industry or commerce than in that of the fisheries. Many fortunes have been made and as many have been lost.

God, the great Creator, has very bountifully provided for his creatures, both on land and sea, and given to man the cunning of entrapping the denizens of the seas as food. As populations increased so the demand for fish food increased, accordingly markets were established and both catchers and venders reaped great harvests. It was soon found that to keep markets supplied larger vessels had to be built to go farther afield for fish, and indeed the fishermen did not confine themselves to their own coasts, but they invaded the shores of other nations, which led to dispute and legislation.

Many acts were passed by the various governments to regulate the fisheries of their own coasts, but nothing of an international character has ever been attempted which has worked more satisfactorily than the international convention of 1882 in the North Sea, although there are improvements to be made even in this.

Territorial waters or sea fishery limits have for many centuries occupied the minds of maritime nations. As far back as 1200 King John claimed dominion over the British seas, so did Edward I and Edward II. The sovereignty included many rights and privileges, of which fishing was one, but foreigners were allowed to fish along the British coasts. In 1295 King Edward I commanded the authorities at Yarmouth to treat foreign fishermen in a friendly and kind spirit while fishing off Yarmouth, and freedom of fishing in the seas was embodied in various treaties between England, France, Spain, Portugal, and Flanders. In 1493 the Pope issued a bull dividing the seas between Spain and Portugal. Spain became ruler over the Pacific and the Gulf of Mexico, while Portugal reigned over the Atlantic south of Morocco and over the Indian Ocean.

During the reign of Elizabeth most of the seas were claimed by one nation or another. Denmark claimed the seas between Norway and Iceland, as well as the Sound, the Belts, and the Baltic. England claimed the English Channel, Bay of Biscay, and the seas westward of Ireland and north of Scotland; also the whole North Sea. These claims included the rights of fishing, and led to

frequent international disputes. The British fisheries declined, and the Dutch increased, and eventually the British assailed the Dutch for fishing off the British coast, and proclaimed the exclusive fishing rights in the British seas. In 1609 King James issued a proclamation forbidding foreigners from fishing on any British coasts unless they had first obtained licenses to do so. This proclamation was renewed by Charles I in 1636. Time and space will not permit of any further reference to the history of territorial limits. The North Sea convention of 1882 decided the present 3-mile limit. This international law has worked well, although a 4-mile limit would have given greater satisfaction to some nations. It has to be remembered that the English mile is not a standard in all countries. For instance, 4 English miles are equal to a Norwegian mile, to a Danish mile, and to a Swedish mile, so that at present the restricted waters are a portion of a mile in each of those countries, and in their case the distance is taken as one minute of a degree. Both Norway and Sweden would have become parties to the convention had the 4-mile limit been accepted, and there are other reasons favorable to that distance. In the first place such a limit would have been as easily ascertainable as the 3-mile limit; it would have given an additional mile round the land for the development of the fry, which are generally found in shallow water, and it would secure to the local fisherman another mile of fishing water. This 4-mile limit would also have served the purpose of customs limitations for contraband, for boarding by cruisers, etc. A governing power on the high seas is absolutely essential, and such a tribunal should be international. The North Sea convention will serve as a criterion.

If the limits could be extended so as to apply to all nations the result would be very beneficial. The lettering and numbering of fishing vessels which is insisted upon has proved a very wise precaution, and fishing vessels are given their due exemption from pilotage, and the rules of the road regarding them are defined. The letters and numbers served the purpose with the sailing vessels, when they were painted on the sails as well as on the hull of the vessel. Now that the steam trawler predominates, the numbers and letters are placed on the bows, and in some cases on the funnels.

The number of steam trawlers to the end of 1907, published by the Board of Agriculture and Fisheries, July, 1908, is as follows:

Belgium	23
Denmark	5
France	224
Germany	239
Netherlands	81
Norway	20
Portugal	13
Spain	18
Sweden	11
England and Wales	1,317
Scotland	292
Ireland	6
Total	2,249

Besides these steamers there are in Norway, Sweden, Denmark, and Iceland a multitude of motor boats for fishing along the shore.

The police or superintendence and protection of fisheries by cruisers has been more or less successful, and it would be well to reconsider carefully the duties and the administration of the power invested in the commanders and officers of the cruisers, as well as the magistrates who have to mete out penalties for infractions of the law. This also is a matter for an international fisheries society to deliberate on. "Regulations for Maintaining Good Order Among the Fisheries at Sea," April 6, 1889, has had only a limited effect, as it is practically embodied in the sea fisheries acts of 1882, but, on the other hand, the North Sea fisheries act, 1893, respecting the liquor traffic in the North Sea, has been a great blessing and a boon both to the owners of fishing vessels and to the fishermen themselves. It has practically annihilated the "cooper," with spirituous liquors and tobacco, and the tobacco has been transferred to the mission ships belonging to the Royal National Mission to Deep Sea Fishermen, from which tobacco can be bought for 1 shilling per pound, equally as cheap as from the "cooper."

The one unfortunate result which has arisen in contravention to the international convention of 1882 came from a desire to close the Moray Firth against all steam trawling, the plea being that this piece of water was the spawning ground for flatfish. In reality there was another feeling emanating from the fishermen who carried on long-line fishing in the Firth of Forth, and those fishermen made representations to the Fishery Board for Scotland to stop this trawling in the Firth. This board accordingly passed a by-law prohibiting trawling. Power was sought and obtained from the British Government and it became a statute. The English trawlers were seized in the Firth, skippers arrested, fish confiscated, and trawling gear removed from the vessels. The owners were heavily fined, but the foreign trawlers insisted upon their rights to fish when outside the 3-mile limit and inside the imaginary line drawn from point to point, a distance of over 70 miles, instead of the 10-mile bay. When it became known that the foreign trawlers could carry on their operations under the protection of the international agreement or convention, the English began to register their ships under foreign flags. There are to-day 35 steam trawlers sailing under the Norwegian flag out of Grimsby, practically owned by Englishmen and worked by them for the sole purpose of trawling in the Moray Firth. This action has caused much enmity between the Scotch fishermen, as well as the Fishery Board for Scotland, and the English trawlers under the Norwegian flag. Of course, English trawlers should observe the fishing rights of the long-line fishermen and also those of the drifters as well as the preserved ground or waters for scientific purposes; but, on the other hand, the Fishery Board for Scotland had no legal right to encroach upon the North Sea outside of the teritorial limits, which is under the common jurisdiction of the high contracting parties and this tribunal

was not consulted. This matter is not settled yet. This is also a case for an international society to settle by arbitration free from political bias.

At the International Fisheries Exhibition, London, in 1883, a statement was made by our much esteemed and lamented friend, Prof. Brown Goode, of the United States Fisheries Bureau. He said: "As long ago as the year 1600, within forty years of the settlement in New England, there were records of the colonists seining the mackerel off Cape Cod by moonlight; and it was somewhat remarkable that on this fishery was founded the system of public schools in the United States, for within ten or twenty years of that time the first public school was founded on a tax upon the fishery." It is not my intention to touch upon the American fisheries; it would be presumptuous to do more than eulogize the rapid progress and the enormous success accruing from the excellent management and regulations in the vast territory of that part of our globe. Such men as my friends Capt. J. W. Collins and Prof. Brown Goode, whom I have already named, have done much for the American fisheries and have enriched all other nations by their original research and publications. Their names will live when many of us have finished our careers.

NOTE.—Appended to Mr. Olsen's remarks were reprints of the following documents as published in his Fishermen's Nautical Almanac:

Digest of the Merchant Shipping Act, 1894 (57 and 58 Vict., ch. 60).
North Sea Fisheries Act, 1893.
Extract from the Sea Fisheries Act, 1883.

DISCUSSION.

Mr. CHARLES E. FRYER. Mr. President, ladies, and gentlemen, I am sure we are much obliged to Mr. Olsen for the paper he has read. It has occurred to me, in the course of the reading of it, that it might possibly be a little local in its character, and refer too much to matters in which we on the other side of the Atlantic are more interested than you who are separated from us by so many miles of deep and, as I know to the full within the last few days, tempestuous water.

The question of the international regulation of the fisheries on the high seas involves, I need hardly say, many very wide considerations. The first point to determine, no doubt, is whether it is the fish and the methods of catching them that you wish to take into account, or whether it is the more immediate interests of those who go in pursuit of the fish, namely, the fishermen.

Where the fisheries are conducted over such enormous areas as the ocean, and not merely in the limited waters of rivers and estuaries, it almost follows that any steps that may be suggested for the protection of the fish must be both less necessary and more difficult to put into operation than any steps that may be taken for the protection of the fishermen; and I submit that so far as the high seas are concerned—and the title of the paper rather limits us to the high seas—the possibility of any international regulation is very much greater when we come to deal with such questions as the protection of life, and the maintenance of law and order among the fishermen, than when we come to consider the possibility of protecting the fish themselves.

The fisheries carried on in the high seas are to a large extent concerned with fish of whose habits we know very little. Notwithstanding all that has been done here in this great country—probably more than in the rest of the world put together—we still find that we are exceedingly ignorant of the minutiæ of the habits and of the habitat of the fish which constitute the great harvest of the sea. The more we know, the more I think we find we need to know, and there is an enormous field of research to be exploited before we can decide whether any protective measures should be adopted for the furtherance of the fisheries carried on in the high seas, more particularly with reference to those fish which are classed as pelagic rather than those which are more local in their habits. The first consideration, therefore, would be to decide upon a method of investigation; and, if I may take a leaf out of Mr. Olsen's book and refer somewhat to what is taking place in western Europe, I may perhaps find a wider illustration of what is sought than can be found on this side of the Atlantic. You here in the United States are in the happy position of having very few neighbors—so far, at any rate, as the flag goes—to deal with. On the other side of the Atlantic we have a large number of nations—separate nations—each under its own separate government, interested in the fisheries in a relatively small portion of the sea, and it has become a much more important question with us to consider whether anything can be done for the protection and development of the fisheries—the fish themselves—than can be the case, or, at any rate, than has hitherto been found to be the case, in this country. For I am afraid to say how many centuries the British statute book alone has been filled with enactments, first for the promotion of the fisheries, and then for the protection of them; and the protection of them in the double sense of the word, with a big "P"—the protection of them against the foreigner; and with a small "p"—the protection of them against the depredations of what are held to be detrimental modes of fishing. For centuries we have been putting laws on the statute book, and we have been equally ready to wipe them out. We have found that we have made regulations in many cases—

in most cases—without sufficient information; and then, having made regulations, we have had to set to work to a very much larger extent to find out whether they are justified by the facts before us. But in recent years we have been somewhat altering our methods, and there is now established, as regards the principal powers of western Europe who are interested in the fisheries of the North Sea, the German Ocean, an international council for the study of the sea. That council started with a very large programme of research, involving many matters, which those who are interested in fisheries know are concerned with fishery development, and which influence the movements of fish, such as temperatures, currents, depths, salinity, and generally what is summed up in the word "oceanography." But, while all these matters are necessarily involved in the great question of fishing and fisheries, they are not necessarily essential to the study of some of the more important problems that we have to deal with, and the international council which has been established with regard to the North Sea is finding that it has to limit its programme and to take up some of the more pressing and urgent questions, rather than to deal with the study of fish and fisheries of the ocean at large. And I should like very much if, in what I am saying, I could lead some gentleman on this side to tell us how far individual cases of urgent necessity have arisen where particular fisheries seem to require protection as contrasted with the wider study of the general questions of biology and of the metabolism of the sea generally.

Having decided whether it is the fish or the fishermen that most require protection, it is for the states concerned in any fisheries which are common to them, as they necessarily are on the high seas beyond the territorial limits, to make up their minds as to the extent to which any regulations are needed and as to the direction which they should take.

It may possibly be of interest to you here if I point out that, so far as any international regulations on the other side of the Atlantic are concerned, in which England—the United Kingdom—at any rate, is interested, there is none which deals directly with the protection of the fish. The regulations deal with the protection of the fishermen; sometimes protection of the fishermen against themselves; sometimes the protection of the fishermen against the elements; sometimes against undue competition, competition carried to the extent of what are commonly, or have in the past, been known as "outrages" committed on the persons and on the property of competing fishermen. Our international regulations have been directed to putting down abuses of that kind and to establishing a system of international marine police which, on the one hand, should protect the territorial limits, but which is mainly established for the purpose of protecting the fishermen and preventing such "lewd outrages" as Mr. Olsen referred to, such undesirable practices as took place when the class of men known as the "coopers," of whom you have heard, practically had the high seas to themselves and carried on a most undesirable traffic in intoxicating liquors, leading to very serious outrages, and, in many cases, to disaster. That has been entirely put down. The moment that these practices were recognized, the several nations interested agreed at once, without any demur, to establish a system of police and a method of license by which the traffic in intoxicating liquors among fishermen on the high seas, at any rate in that part of the sea which was particularly infested by these men, should be controlled.

Then, as another instance of undesirable practices, is what you, I believe, on the United States coast know as the trawler, here practically unknown—that is to say, the trawler who fishes with a net drawn along the bottom of the sea. I believe I am right in assuming that by the trawl on this side is commonly meant the long line?

The PRESIDENT. Yes.

Mr. FRYER. But on the other side of the Atlantic the practice of trawling by nets whose mouths are held open by one or two very ingenious devices and which are drawn along the bottom—at or near the bottom—of the sea, is a practice which is extending enormously. I am told that one or two experiments have been made on the Nova Scotian coast, and I hear that it is proposed to send over some of these vessels to the banks on this side—the Newfoundland banks in particular—with a view to seeing

whether that industry can be established on this side. Thus you may possibly have in a very short time to deal with difficulties such as we have had to deal with, namely, the interference caused by a method of fishing, such as the trawl, with older-established methods, such as the long line, or what you know as the "bultow" or with the "drift net."

When steam was introduced as a means of propulsion of trawling vessels, it became very much more easy for the trawler to force its way through the drift nets, or to sweep up the long lines, than when a vessel was propelled merely by sail. And a very reprehensible practice was adopted by a certain number of fishermen who actually carried with them to sea cutting grapnels, which enabled them to cut into the nets with which they came in contact, and very great damage was done by one class of fishermen to another class in this way. This is an illustration of the protection of fishermen against their colleagues. Now, as soon as this practice was brought to the notice of the powers interested, in the North Sea fisheries especially, they again entered into an international agreement to put this practice down, and heavy penalties were imposed upon the possession of the instrument in question, which was known by the somewhat significant title of "devil." The devil has been abolished, in that shape at any event, from the North Sea.

I do not know whether I am passing the time limit or not.

The PRESIDENT. Just a minute or two more.

Mr. FRYER. One other matter in which it is possible to protect the fishermen is with respect to the outfit of the vessels, and the prevention of collisions at sea, and in things of that sort, which also have become the subject of international regulation. In such questions as the carrying of lights for particular purposes, not only the nations of western Europe but practically all the nations of the world have agreed to an international code, which I think I may refer to fairly as an illustration of the link which exists among all nations in the waters of the high seas in which the great fisheries are prosecuted.

I should like to enlarge upon the idea which suggests itself as soon as we begin to speak of the ocean as a link. We speak of it commonly as a means of division between nations, but I think that the suggestion may be maintained that the water is rather a connecting link. It is much more a connecting link than it is a means of dividing of the nations. In this room we have an illustration of the fact that the subject of fish, and the element in which the fisheries are conducted, has led to the bringing together of a large body of gentlemen from all parts of the world; and if the question of the international regulation for fisheries on the high seas can lead, as I hope it may in the future, to more harmonious and fraternal relations among the nations of the earth, we shall be entering upon quite a different era from that of the past, when the question of fisheries was a question sometimes nearly, if not actually, of war, and led at any rate to anything but fraternal relations. But I think the longer we study and the more we know of these matters, the more we regard them from the point of view not of our own local interests, but as interests uniting nation to nation, the better it will be, not only for the fishers themselves, but for the general welfare of those nations who are so largely interested in them in common. [Applause.]

Dr. B. W. EVERMANN (U. S. Bureau of Fisheries). Ladies and gentlemen of the congress, this matter of the international control of the fisheries on the high seas suggests to me that it might be worth while for a word to be said regarding a step which the Governments of Great Britain and the United States have recently taken looking to the control of the fisheries in international waters. As you are doubtless aware, the fisheries in the international waters between the United States and Canada are of great importance. There are a number of important lakes—four of the Great Lakes, and smaller lakes connected with them—the St. Lawrence River and those other waters to the eastward; and then of equal or even greater importance are the fisheries on the west coast, those in the Puget Sound and Fraser River region. The fisheries in those international waters

have been administered by the respective States on this side of the line and by the Provinces on the other side, in some cases jointly by the Provinces and the Dominion Government.

Lake Erie may be taken as an illustration. On the American side are the States of New York, Pennsylvania, Ohio, and Michigan; on the other side the Province of Ontario. Each of those governments has exercised control over a certain portion of Lake Erie. The laws or statutes in no two of those States or provinces have been uniform. As a result, interminable and very irritating conflicts arise every year. Because of that situation, recently the United States and Great Britain entered into a treaty, the terms of which provided for the appointment of an international fisheries commission to look over the ground, to find out what the local conditions are, and to recommend to the respective governments proper statutes which would regulate in a proper way the fisheries of these international waters. The treaty named specifically the waters which were to be considered by this joint commission. The treaty also provided that this international fisheries commission should write the statutes, define what should be the terms under which fishing may be carried on in these various waters, and that they should submit their report to the respective governments not later than the 31st of December next. Then it is understood that the statutes written by that commission will be promulgated by the respective governments and the necessary steps taken for the enforcement of the regulations agreed upon.

The short time that was allowed the commission to consider these matters was embarrassing, of course. To allow them only until the 31st of December seemed a very short time; at first blush it seemed that it was almost useless to attempt to do anything, but the commission entered upon its investigations at Eastport, Me., the 7th of July. After a few days the situation cleared up very materially. I may say that the commission took as the basis from which to work the most admirable report made by the Rathbun-Wakeham commission of 1892–1896. Those two gentlemen, as high joint commissioners, representing the two governments, Canada and the United States, went over the ground during each of four years and made a very thorough and very sane report as to the conditions, and then closed their consideration of each of the international waters with a statement embodying what they thought were the proper recommendations necessary to be carried out for the proper regulation of the fisheries of that particular body of water. Using that as a basis, the present international commission was able to make much more rapid progress and to understand the situation much more readily and much more thoroughly than at first seemed possible. After interviewing a few hundred fishermen it was easy to tell what the next fisherman would say, so that the matter became simple. I may say, simply, that this international commission, consisting of David Starr Jordan, of Stanford University, California, and Samuel T. Bastedo, of Canada, with myself as associate, went over the entire boundary, visiting all of the important fisheries, and the commission is now writing its statutes and will have its report ready for the respective governments by the end of December.

What I want to call to your attention particularly is this: Practically all of the difficult problems which came to the attention of this commission were biological problems. They are problems which can not be settled or solved offhand. They are problems which can be settled or which can be understood only through a series of careful observations; the time of the spawning of the different species of fishes, the food of the different species of food fishes, and I may say, and strangely, just what are the species of food fishes in the Great Lakes. They are not what they are said to be in the books. There is a discrepancy; there are several discrepancies, in fact. So that the problems which must be studied from now on, which will need to be studied in order to revise and revamp the statutes from time to time, as the international commission has authority to do, are problems of that character; and they will have to be taken up from year to year to keep the statutes up with the ever-changing conditions.

This, it seems to me, the taking over of the control of the fisheries on the Great Lakes by the federal governments—by the United States Government on our side, and the Dominion Government on the other side—is a great step, the greatest step that has ever been taken, I think, looking toward the proper conservation and the building up of the fisheries.

The terms of the treaty are numerous, and if they are carried out—and the governments are sure to do it, I think—we feel that the outlook for the fisheries in these international waters is more encouraging than it has ever been. Thank you. [Applause].

Mr. A. KELLY EVANS (Canada). I would like to amplify something that Doctor Evermann alluded to.

In speaking for the Province of Ontario, which virtually controls the major Canadian portion of the great inland fisheries, I should like to explain one point that Doctor Evermann has left out, as showing the great advantage accruing through this new treaty, and the matter being left in the hands of the commission.

Unfortunately, it has been the practice in the past that persons at certain local points, governed by certain local political conditions, were able to place regulations upon the statute book which undoubtedly were very much against the conservation of the fisheries of the inland lakes. Having now placed the power in the hands of a commission, it will be impossible, for instance, for the local representative of one constituency to have his own way as has unfortunately often occurred. As an illustration, take a small body of water which it so happens occupies the position of the most favorable spawning ground for the fish of a very large body of water—for example, in Lake Ontario we have the Bay of Quinte, a small, narrow, land-locked bay in which most of the white fish of the entire lake spawn. At present some 300 or 400 net fishermen practically determine a member for a constituency there and have been able to dictate terms to that member. Now that this matter is placed in the hands of a commission, you will see that the member representing that one constituency will have but little or no power over the regulations governing the fisheries, etc., and consequently the net fishermen, for their own temporary, selfish interests, will not be able to dictate the policy governing the fisheries of the Great Lakes.

Unfortunately, the map that is exposed on the wall is rather broken off here [indicating] and it does not show a large portion of our Canadian fisheries to the right, and also owing to the coloration you hardly catch the immense coast line of these Great Lakes; but the coast line of the Great Lakes on our side in Ontario alone is much greater than your American coast on the New England seaboard. And these waters, which but a few years ago teemed with fish in masses that are almost unbelievable, at the present time have reached a point nearing depletion. In this smallest of the Great Lakes here, Ontario, but a few years ago as many as 90,000 whitefish have been taken in one haul with a net. To-day the whitefish fishery in this lake has practically ceased to exist; and I may say that the depletion of the whitefish of Lake Ontario is due very largely to the political influence of some 300 net fishermen in the little constituency of Prince Edward County.

The same thing applies to other of our waters. That peninsula up there [indicating] in North Bruce is also the governing point of important breeding grounds for fish, and the net fishermen there can exercise direct political influence upon their member in parliament. The consequence is that in our country we have this anomaly, that to suit these local political exigencies actually we had an open season there [indicating] different from the open season here [indicating] and different from the open season there [indicating]. In other words, those net fishermen who could bring sufficient political weight to bear upon their member in parliament were enabled to have the fishing season extended into the dangerous breeding zone and otherwise influence the fishery regulations. Now, fortunately, these men, when they come to Ottawa asking for certain favors for their own particular constituency, will be swamped; and we do feel—and I take great pleasure in amplifying what Professor Evermann has said—we

do feel that for the future we may expect that, largely through this treaty and through the work of this commission, the fisheries of the Great Lakes will be saved to posterity. [Applause.]

Mr. JOHN J. PEW (Massachusetts). Mr. President and fellow-delegates, having been interested in the fisheries from boyhood and having had many generations of my ancestors engaged in the same business, as a delegate from the largest fishing port in the United States I feel compelled to bring before this body the matter of beam trawling.

It is the question of beam trawling as now pursued. Several trawlers equipped with beam trawls have already been operating on the banks off the coast of New England, Nova Scotia, and Newfoundland. This method of fishing is looked upon with great alarm and anxiety by all the experienced fishermen of New England and Canada, as far as I am informed; not, as I believe, on account of any spirit of jealousy or on account of any temporary success that any of the beam trawlers may have achieved in the above-mentioned waters, but on account of the catching of so many small fish, which after being taken are found too small for use and are then thrown back in the sea, thus destroying many millions of fish which in a few years if left alone would grow larger and assist in keeping up a continual supply of a catchable and profitable fish for commercial use.

Allow me here to cite an interview with a captain of a Gloucester vessel by a reporter of one of our Gloucester papers. Knowing the captain as I do, I can speak for his reliability and experience in regard to the deep-sea fisheries.

Captain Geel says the greatest menace to the fishery on the banks is the fleet of steam trawlers which have been sweeping over it this season. No one is more qualified to speak than this captain. He says that the damage these crafts are doing may not be apparent right away, but if continued will surely play out the banks as places for the usual method of fishing. Said he:

> Why, you just imagine it! They sweep over the shoal spots steadily, dragging and hauling and setting, dragging, hauling, and setting that great trawl day and night, working two gangs. Now, they do not save any fish under 22 inches in length. They dump the contents of the trawl on deck, pick out the fish over this length, then open the big ports in the bulwarks and dump all the rest of the catch, dead, of course, back into the sea. I do not know what we can do about it; but you take my word for it, it means the beginning of the end of our valuable fisheries if something is not done soon.

Also allow me to cite an extract from a Boston paper of September 11 in regard to steam trawlers:

> HALIFAX, NOVA SCOTIA, *September 11*.
>
> Fishing by means of steam trawlers within the bays and harbors or within the 3-mile limit of Canada has been prohibited by an order in council passed by the Canadian government. The fishermen of Nova Scotia made strong protests to the government against the operation of trawlers, one of which, the *Wren*, recently arrived from Scotland and was fishing out of Canso, Nova Scotia, manned by a crew of North Sea fishermen. This means of fishing is largely used in the North Sea, and as a beginning had been made to introduce it in the waters of Canada the government has taken prompt action to stop it. It is so effective that the above order had to be made to prevent the extermination or serious diminution of the fish supply.

In New England there is only one steam trawler engaged in the beam-trawl fishing, and I am informed it is the opinion of those interested in this vessel that this method is considered destructive to small fish and harmful to the best interests of the New England fisheries for the future.

I do not feel like going into a long argument about this method of fishing, but wish to call your attention to this matter and appeal to you whether it is not time for you to consider it in all of its bearings and take some action which will result in a speedy investigation of the whole matter, that will tend to some regulation or restriction by your respective governments, and be the means of saving millions of small fish from extermination, the loss of which would diminish the catch in the coming years and result in serious losses to all persons engaged in the fisheries.

The PRESIDENT. This opens up a very important matter that is new to America and old to Europe. Are there some who are well acquainted with the situation in the North Sea who will contribute? Doctor Hoek, is it well for us to attempt to secure any preventive methods at present?

Doctor HOEK. I hardly believe that.

The PRESIDENT. You hardly believe that? Must we wait until it gets a little more serious?

Doctor HOEK. Mr. President, in the North Sea they have been trawling now for such a long time, have they not? And the same complaints that just now have been brought forward have been put forth on twenty-five different occasions—on two hundred and fifty occasions. In several instances investigations have been made, and we have at the present moment an immense bulk of information, but hardly one of us dares to come forward with a conclusion, so difficult is the matter. It is so easy to say when a little fish is killed, "Oh, it is a pity," and when a large quantity of young fish is killed to say it should not be permitted; yet it is a very curious thing that taken as a whole the quantity of flatfish taken from the North Sea of late years, while it is diminished, is by no means (so far as statistical information goes) so greatly diminished as you would expect from the alarming communications we have had for several years already on that point. I hardly believe we are sufficiently prepared here to discuss this difficult problem, and so I should prefer not to go into the details of the question, Mr. President.

The PRESIDENT. We are very much obliged.

Mr. PAUL NORTH. Would it be possible to prevent the deep-sea trawling on the open seas—on the bank would it be a possibility?

The PRESIDENT. You have heard the question of Mr. North. Is anyone here prepared to answer him?

Mr. FRYER. Mr. President, I must congratulate you upon your skill as an angler. I never saw a fly more adroitly thrown over any fish than the fly you threw over Doctor Hoek; and I must equally congratulate Doctor Hoek upon having disposed in five sentences of so vast a question as that of the use and the alleged abuse of the trawl. I would only add to what he said that you should not only throw your fly over Doctor Hoek, but that you should keep your eye upon the work that he and his colleagues in Europe have been doing in investigating this question of trawling, more particularly in the North Sea.

Of all the fisheries problems, so far as the high seas are concerned, the problem which is attracting the attention of the great fishing powers on the other side of the Atlantic is with regard to the question of the trawl. I think the answer to the question, "Whether it is possible to pass laws prohibiting trawling?" is undoubtedly in the affirmative. It is perfectly possible to pass laws prohibiting trawling, and it is perfectly possible to enforce those laws within the territorial limits, provided you have got (I hope I am not treading on dangerous ground) a navy big enough to do it [laughter]; but to prohibit trawling in the extraterritorial waters, the waters in which international regulations are necessary, is quite another matter; and there, again, I would suggest that you watch very carefully the results of the investigations that have been conducted for the last seven years—investigations which some of the originators thought might have been brought to an end in less than half that period, but which they are recognizing must be carried on for a considerable period yet before even the answer to a single question can be given, namely, whether trawling is or is not detrimental.

Mr. C. H. WILSON (New York). I wanted to say that our Canadian friends have made a confession here, through their able advocate, Mr. Evans, of Ontario. I think it decidedly un-American that we of the United States should not come halfway in admitting the fact that the fisheries of the Great Lakes on the United States side show quite the same percentage of depletion as those of the Dominion of Canada. I speak by the book. Take the catch of whitefish alone on the Great Lakes, including St.

Clair. The report of 1880 shows a catch of 21,463,900 pounds. In 1903 the catch had dwindled to 3,813,259 pounds. In the State of Michigan the reports of its fisheries are as follows: The whitefish catch in 1891 was 8,110,000 pounds; in 1904 the catch was 4,197,000 pounds, and other varieties of food fish suffered a like loss during that period.

The question of international control of the waters contiguous to the United States and Canada is a question that has disturbed the heart and soul of the average American citizen in a painful manner. We have seen year by year the reduction of the catch of the various varieties of food fish in those lakes. Worse than that, we have seen the continuous rise in the price of food-fish products, menacing the poor.

The settlement of this question is a consummation devoutly to be wished, not any more so by anyone than by the citizens of the State of New York. [Applause.]

Mr. HENRY HINRICHS (Pennsylvania). Regarding the decrease in the catches of fish on the Great Lakes, I regret very much that the gentleman who preceded me failed to take into consideration that last year (1907) and this year there was a phenomenal increase in the catches of whitefish. My home is Erie, Pa. I am interested in the fishing there. Whitefish were considered practically extinct. We did not deem it advisable, from a pecuniary point of view, to invest any money in fitting out nets for the purpose of catching whitefish. Last year and this spring, however, exceptional catches of whitefish have been made. The blue pike, another of the common-food fishes, were decidedly on the increase last year. Extremely heavy catches were made all along the south shore of Lake Erie. This year the herring, the most common fish that swims in the waters of the Great Lakes, have been found more abundant than ever in the history of fishing. There seems to be no end to them; and as far as the price to consumers is concerned, to which the distinguished gentleman referred, I wish to say that the scarcity of fish naturally affects the price. Owing to the heavy catches that have been made this year, at least on Lake Erie, the prices have been lower by from 50 to 75 per cent in some instances than in a great number of years.

Whether this phenomenal increase in the catch of food fishes on the Great Lakes is to be attributed to artificial propagation, or to the exceedingly warm weather of this summer, I am not sure. However, I believe that artificial propagation is perfectly justified in laying claim to the phenomenal increase.

INTERNATIONAL REGULATIONS OF THE FISHERIES ON THE HIGH SEAS

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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PRIVILEGES AND CLAIMS OF THE FLAG.

The same principle by which the protection of the flag of its proper nationality is afforded to a vessel on the high seas beyond the territorial limits of its country requires that vessel to comply with all the laws of its country, whether applicable within or beyond territorial limits, and it is as much within the competence of any power to impose restrictions on fishing operations carried on by vessels flying its flag in any part of the world, outside of the territorial waters of other nations, as it is to regulate the fisheries within its own rivers and elsewhere within its domain. But however admirable or necessary such restrictions might be, they would necessarily apply only to the subjects or citizens of the particular State that enacted them, and could not be enforced against aliens except by consent. In cases, therefore, where the fisheries prosecuted in extraterritorial waters were shared in by fishermen of other states, great hardship would result unless by international agreement the same regulations were made applicable to all fishermen alike, of whatever nationality.

NECESSITY FOR COMBINED ACTION.

The hardship thus involved recently received curious illustration in the effects of a self-denying ordinance which the herring and mackerel fishermen of the county of Cornwall (England) imposed upon themselves in the matter of Sunday fishing. For various reasons, partly religious, partly social, partly economic, the Cornishmen agreed to regard Sunday as a day of rest from fishing and to discountenance not only fishing operations, but also the task of departure for or return to the fishing grounds on the Sabbath day.

This understanding was loyally adhered to until the advent of large numbers of competitors from east-coast ports, who, making Cornish harbors their temporary headquarters, sought to gather in the harvest of the sea as quickly as possible. Not being actuated by the same scruples as the west-country folk, and not being in any way parties to the understanding, the newcomers did not feel

themselves called upon to abstain from Sunday fishing; and, notwithstanding all appeals, they declined to discontinue their labors on the Sabbath. So much resentment was engendered among the Cornishmen that, not being inclined to surrender their principles, but having no lawful means of imposing them on their visitors, they had recourse to acts of violence, and considerable rioting was the consequence. In the absence of laws to the contrary the east-country boats were, of course, as much entitled to fish on Sunday as the west-country boats were to abstain; and, short of mutual agreement, the only way of settling the dispute would have been to pass a law making Sunday fishing illegal on the part of all British subjects, at any rate in the particular portions of the sea in respect to which the trouble had arisen. But while this would, so far, have ended the controversy as between British subjects, it would have resulted in a possibly greater grievance and a certainly greater anomaly, since the waters in question are frequented by both British and foreign fishermen. It was one thing for the Cornishman voluntarily to abstain from fishing on Sunday and to leave the ground free to such of his foreign rivals as chose to fish there in his absence—especially seeing that the fish so caught were not brought into the Cornish markets, but it would have been quite another thing to compel the east-country fisherman to desist from catching fish which he was anxious to catch, while the foreigner was under no such disability—especially seeing that it was not pretended that the prohibition of Sunday fishing would have benefited the fisheries as a whole. Without in any way going into the merits of the dispute, it is obvious that no form of compulsion in this case would have been tolerable, if effective, which was not of universal application, and this could be brought about only by the common consent of all the States whose fishermen frequented the grounds in question.

MAIN OBJECTS OF INTERNATIONAL REGULATIONS.

It seems obvious that, in waters in which the fishermen of any considerable number of different nationalities are largely concerned in fishing at the same time, not only will there be the greatest necessity for international agreement and regulation, but there must exist the greatest diversity of interest, and the greatest difficulty will be encountered in devising rules that will be mutually acceptable. It is therefore, perhaps, not out of place to consider what have been the history, objects, and results of such international regulations as have been framed for waters which answer most fully to the above description.

In none of the seas of the world are such extensive and diverse fishing operations carried on at the same time by so large a number of fishermen, of so many various nationalities as in the extraterritorial waters of the English Channel and the North Sea or German Ocean. Prolific of fish in great variety and of the finest quality, and easily accessible to vessels of all sizes belonging to at least eight different powers of western Europe whose shores it washes,

the North Sea in particular has for centuries been the resort of an ever-increasing number of fishing craft of different nationalities; and, with an ever-growing demand for the product of their industry, and with the increasing power and size of their vessels, especially since the introduction of steam, not only have the fishermen been brought into closer and more frequent contact with each other, over wider areas, but the opportunities, if not the need, for interchange of commodities between them have also been enlarged. It is natural, therefore, that we should find in the case of the North Sea fisheries a greater diversity than elsewhere of purposes for which international regulations have been called for in relation to the better government, more orderly conduct, and greater prosperity of those engaged in their prosecution.

The main objects toward which the regulations of this character have been directed have been fourfold: (1) The protection or further development of the fishing industry, as such; (2) the protection of the gear of the fishermen against injury; (3) the maintenance of law and order among fishermen; (4) the greater security of the lives and persons of the fishermen. These objects are, almost of necessity, the same as those which are aimed at in all fishery legislation, whether in inland waters or elsewhere, but their relative importance is practically reversed in the case of fisheries on the high seas as contrasted with what may be called the "domestic" or "national" fisheries. In the latter case, and more particularly in regard to river fisheries, not only are the effects of overfishing more readily made manifest, and the necessity for protection recognized, but the national laws, whether for the development of the particular industry or for the security of the property involved, are more easily enforced against all persons alike than in extraterritorial waters where differences of custom, of methods, of laws, and of language—to say nothing of interests—bring about unavoidable complications. Two nations whose fishermen practice different methods of fishing for the same kind of fish will not always admit that the same necessity exists for its protection or that the same remedy is the appropriate one. Each class of fishermen will probably attribute mischief to the method of fishing adopted by the others, and the mutual jealousies which exist between, for example, the seiners and the drifters, or the trawlers and the line fishermen, of the same nation—each attributing to the acts of the other any falling off in the productiveness of the fisheries—are intensified when to difference of method is added difference of race. Hence the cases are rare in which international agreement has been arrived at with respect to regulations aimed directly at the protection of fish against overfishing, alleged or real, on the high seas.

The instances of the conventions between the United States and Canada for the preservation of the fisheries of the Great Lakes, or of the agreements between Germany, Holland, and Switzerland with respect to the salmon fisheries of the Rhine, are not appropriate to the present essay, since they relate to inland waters in which no extraterritorial rights are admitted, and not to the high

seas.[a] Perhaps the most prominent instance of the kind in which international regulations were directed to the protection from threatened extermination of a marine animal is that of the treaty dealing with the seal fisheries of Bering Sea.

SEAL FISHERIES.

It may be objected that, although the pursuit of the seal is popularly classed under the head of "fisheries," the seal itself is not a "fish" and does not therefore properly come within the purview of this essay. But a reference to the case is at least admissible on the ground that it serves to bring into prominence the fact already alluded to that international agreements for the protection of fish from overfishing are conspicuously rare in the case of the high seas.

The difficulty of proving the existence and effect of overfishing in the case of fisheries on the high seas is generally recognized; the movements of the fish are not easily traced, the causes of those movements are often unknown, and the direct effect of man's operations, either in influencing those movements or in reducing the available supply of fish, is generally a matter of inference from insufficient data and incapable of proof. But in the case of the seal we are dealing with an animal whose movements at the most critical periods of its career are open to view and easily observed; whose numbers are capable of ascertainment by means of a census sufficiently accurate for all practical purposes; and on whose destruction a definite limit could be set without serious difficulty. It was therefore comparatively easy in this case to bring home to all the powers interested the necessity for measures of protection and then to induce them to agree on the most obvious restrictions. Whether those restrictions will prove in all respects sufficient for their purpose is a question which only further experience can finally answer, but their promise of success is sufficient to encourage the hope that the end in view will be achieved, and furthermore that the increase of knowledge as to the habits of fish and as to man's influence upon them will be made the basis of any analogous steps that may be proposed for international action toward the prevention of overfishing in the case of fish properly so-called.

It may be interesting to note, in this connection, that thirty years ago, by agreement between the United Kingdom and the Scandinavian powers interested in the seal fisheries of Greenland, the killing of seals on and near the coasts of that country was prohibited in any season until a date at which it was estimated that the young cubs would be able to provide for themselves, and it is believed that the supply of seals in the waters in question has considerably increased in consequence.

[a] The omission from this essay of any reference to the international regulations relating to the fisheries carried on in common by the fishermen of the United States, Canada, and Newfoundland is justified on the ground that some of the questions involved are the subject of pending diplomatic negotiations between the powers concerned.

OYSTER FISHERIES OF THE ENGLISH CHANNEL.

The earliest instance of an international agreement for the enforcement of a regulation directed toward the protection of seafish from overfishing occurs in connection with a convention entered into between the United Kingdom and France in 1839, under which regulations were mutually agreed upon for the better ordering of the fisheries carried on by the subjects of those two states in the English Channel. Here, again, the object of the solicitude of the two powers was not a "fish" in the true sense of the word, but a mollusk, namely, the oyster. Here, also, the condition precedent existed that it was comparatively easy to secure adequate evidence of the necessity for some protection against overfishing. This protection took the form of a regulation forbidding the removal of oysters measuring less than 2½ inches across the shell, and of a close season of four months, during which oyster-dredging was forbidden in the extraterritorial waters of the English Channel, while, later on, it was provided that oyster dredges should not be carried on board the fishing boats of either country during the prohibited period, unless kept duly secured by seals affixed by a competent official. The dates fixed for the close season, however, were not altogether the most appropriate, and, by a later convention arranged in 1867 between the two countries, it was agreed that the period should be altered. This latter convention was never ratified by France, and, although England took the necessary steps to give effect to it, it has never been fully put into operation, but the close season for oysters as then determined is maintained by special agreement renewed from year to year.

OTHER ANGLO-FRENCH CONVENTIONS.

By far the greater part of both these Anglo-French conventions, as well as the whole of the more recent conventions relating to the fisheries of the North Sea, deals with the several points included under the heads—other than the protection of fish—into which the objects in view have been divided; and, although international regulations with respect to overfishing are rare, there are numerous instances in which the regulations have dealt with the protection of the fishermen themselves in either their persons, their morals, or their property.

Both the Anglo-French conventions above referred to made provision for identification marks being affixed to fishing boats operating within the English Channel, for keeping certain classes of fishermen as far as practicable apart, so as to minimize the risk of damage or conflict, and for establishing a system of international sea-police for the proper enforcement of the regulations. The great development of fishing operations in the last few years has, apart from other considerations into which it is unnecessary to enter here, rendered obsolete the greater part of the regulations thus agreed upon, and negotiations are now in progress between the two countries for a new convention on wider and more modern lines and more fitted to existing conditions.

NORTH SEA REGULATIONS.

In the meantime a separate series of enactments applicable to the North Sea has been put in force, dealing with a wider range of subjects than were contemplated either in 1839 or in 1867. None of these enactments, however, affects the question of overfishing. They deal with the human aspects of the question only. And, curiously enough, one of the earliest of them was brought about, not by overintensity of rivalry between competing fishermen, leading to acts of hostility, but by undue familiarity based on mistaken notions of friendship and resulting in abuses of a social and moral nature which called for interference.

Out of a system of exchange and barter, at sea, of fish, clothing, and other commodities, there had grown up a practice of sending among the fishing fleets in the North Sea a number of vessels, known as "coopers," specially fitted for the supply of intoxicating liquors, which found a market among certain of the fishermen, being sold for money where cash was available, or exchanged for fish or other articles. Such opportunities were especially frequent in the case of the trawling vessels fishing on what is known as the "fleeting" system. Instead of returning to port after each fishing trip the boats of certain companies fish together on a given ground, where they are visited day by day by specially fitted "carriers" or "cutters" which go the round of the fleet, collect the whole catch, and straightway steam back to deliver it in the fish market, returning again to the fleet and repeating these operations as long as fish remain sufficiently plentiful on the ground. In this way a fleet of trawlers may remain at sea for considerable periods, and in these and other circumstances, due to the development of the industry, the facilities for surreptitious traffic in drink not only led to the fishermen being exposed to great temptation to dishonesty, but conduced to scenes of drunkenness, to acts of violence, to neglect of duty, to insubordination, and to danger and disaster in which other and innocent persons were frequently involved.

The result of all this was a convention between the United Kingdom and certain neighboring powers known as the North Sea Liquor Traffic Convention of 1889, whereby heavy penalties were imposed on any persons supplying intoxicants or tobacco to fishing vessels, except under license from the duly constituted authorities. In practice the issue of these licenses is limited to a few vessels employed as "mission" or "hospital" ships in connection with the trawling fleets, whose visits afford sufficient opportunity for the supply of such liquors as are needed for medicinal and other legitimate purposes. The consequence has been the entire disappearance of the "coopers" and the almost total abolition of the evils which followed in the train of their misdirected enterprise.

Equally satisfactory results have followed on the adoption of other international regulations, for the repression of acts of unprovoked injury to fishing

gear on the high seas, under a convention in which the powers bordering on the North Sea are again concerned jointly, so far as regards that part of the ocean.

In or about the year 1882, very serious complaints were made by British drift-net fishermen in the North Sea that it was the practice of certain foreign trawlers, chiefly Belgian, deliberately to cut through any drift nets that they might encounter and so clear a way for their trawl, continuing on their course without waiting to haul their gear and disentangle the net which they had fouled. For this purpose they carried a specially constructed iron implement, which got to be known as the "Belgian devil," shaped like a three or four pronged grapnel of considerable size, the inner sides of whose prongs or arms were furnished with cutting edges, and which they carried suspended in the water at such a depth that it automatically caught the footrope of the drift net, gathered the net in a loop, and severed it by the mere action of the trawl boat sailing, or steaming, on its course. A committee of inquiry found these complaints to be well founded and the result was an international convention forbidding the use or possession of any such engine for any such purpose under heavy penalties, and the "Belgian devil" has now entirely disappeared from the North Sea.

Abuses of such kinds as either of those just alluded to will, it may be hoped, be rare, but whenever they occur it may be expected that public opinion, in all countries, will readily support decisive and prompt conjoint action for their suppression. It will, however, be always more necessary and more difficult to deal with those other and constantly recurring cases of unavoidable collision, more or less serious, between the boats and the gear of men lawfully and peacefully pursuing their various avocations, with different kinds of engines, in the same waters.

Wherever fishermen are attracted in large numbers to the same fishing grounds, there is always risk of damage from such a cause. In the North Sea alone, such diverse methods of fishing as trawling, seining in various forms, drifting and lining—not to mention other and less important modes—are employed at the same time within a comparatively narrow area, and often for the same kind of fish; and it may easily happen that, with the best intentions in the world, and with every desire to avoid all cause of conflict or dispute, the trawler may foul the nets of the drifter or the lines of the line-fisherman, or the drifter and trawler alike may disturb the seiner.

To minimize such possibilities the International Code of Navigation Laws and of regulations for the lights at sea to be carried by fishing boats at night has done something, and so long as those regulations are observed it is comparatively easy for one boat to avoid collision with another or with its gear. But, even so, occasional collisions are inevitable unless specified areas are set apart on which only one mode of fishing is permitted at one time. Even such a remedy as this would not remove all possibility of collision between boats of

the same kind, and there is the further objection that the reservation of particular areas to particular classes of vessels would involve great difficulty and expense in watching. It is clear, therefore, that after minimizing as far as possible the opportunities of collision by a well-considered system of signals, the next step is to minimize the damage resulting from inevitable casualties and to provide for the restoration of the damaged gear to the owners and for payment of compensation for the injuries inflicted.

With these objects in view the several powers bordering on the North Sea have entered into a series of conventions under which a fairly comprehensive code of regulations has been adopted, providing for the following matters:

(1) The clear delimitation of the areas within which the joint regulations were to apply.

(2) The adoption of easily recognizable marks of identification for both boats and gear.

(3) The protection of a vessel already engaged in fishing from undue interference by another boat arriving on the fishing grounds later.

(4) Provision for the restoration to the owner of gear accidentally carried away or picked up at sea.

(5) Provision for the prosecution of claims for compensation for damage in default of agreement.

(6) The assessment and recovery of damages duly adjudged.

(7) The prohibition of willful damage and enforcement of due diligence and care in releasing gear accidentally fouled.

(8) The enforcement of the regulations by the national vessels of all the contracting powers, with right of arrest in case of necessity.

RESULTS ACHIEVED.

A quarter of a century's experience of the working of this convention—while showing that it is incomplete in many details and is capable of improvement in order to fit it to deal adequately with the changing conditions of the fishing industry—has demonstrated that, given a frank recognition of equal rights, it is possible so to harmonize the apparently conflicting interests of different classes of fishermen, belonging to different nationalities that a spirit of mutual forbearance will take the place of jealousy, ill feeling, and suspicion, and law and order will supplant violence and outrage. In this connection, two conclusions present themselves: (1) That these results can only be obtained by the assertion of the superior force of authority and (2) that a very slight display of the resources of duly constituted government power is sufficient to secure the observance of the regulations. In the absence of such show of authority, however, there will always be men, who, however familiar with the law, and however much accustomed to its observance wherever there is provision for its enforcement, will seize

any opportunity of breaking it with impunity. The spirit underlying the conventions between Great Britain and France as regards the English Channel on the one hand, and between Great Britain and other powers as regards the North Sea on the other, is precisely the same, namely, a desire to secure to the subjects of each separate state the same protection from injury on the high seas that they would expect within the territorial domain of their respective governments. But the machinery for giving effect to this spirit is less complete in the case of the earlier conventions, and the result is that the same men who in the North Sea are careful to observe the law are apt to disregard its principles as soon as they cross the line which divides the North Sea from the English Channel, and as long as they are outside the line which separates territorial from nonterritorial waters.

The moral of this appears to be that, once the authorities are agreed that good cause for interference exists, it is easy to take and to enforce the necessary measures provided they are based on the generally accepted principles of law, order, and morality, and as long as they are founded on sufficient evidence as to the habits of fish and the effect of man's operations. Differences in legal procedure and practice involve a certain amount of difficulty, but in the cases above quoted this has been practically overcome by providing that a person charged with an offense shall be tried in the courts of the country to which he belongs, whatever the nationality of the officer arresting him. In this way mutual confidence in the sincerity of the authorities of the various contracting powers has been inspired; and with increasing evidence of a determination to maintain the ordinary principles of justice and right there have been displayed on the part of the fishermen themselves both a more general appreciation of the value of international regulations and also a sense of the greater security with which they can carry on their industry further and further afield—and this, after all, is only one indication of the increasing prosperity of the industry, which it is the ultimate aim and object of all such regulations to secure.

INCREASING NEED FOR INTERNATIONAL AGREEMENT.

Nevertheless, the greater the success of such regulations in this direction the greater is the variety of other interests involved. The further afield the fishermen of any State go, the more certainly will they be brought into closer relations with the fishermen of fresh nationalities, and the longer will be the list of States which find that they have interests in common—interests which will, sooner or later, call for combined action in the direction of international regulation of the fisheries on the high seas. Whether such regulations should aim at the protection of the fishermen—either in their lives, their property, or their morals—or at the protection of the fisheries against overfishing must depend on circumstances. So far as experience goes, the first object is the one most likely both

to claim attention and to make good its claim. It is far easier to prove that the lives or property of fishermen are in danger than it is to establish any connection between the fishing operations of the fishing fleets and the fluctuations in the yield of the fisheries, especially in the deep seas; and, as a preliminary to any effective steps for the protection of the fisheries on the high seas by way of international regulations, it will be found necessary to provide for international agreement as to the nature and extent of the statistical records to be kept and as to the method and scope of research into those natural phenomena which affect the productiveness of such fisheries more extensively than the combined operations of all the fishing fleets.

INTERNATIONAL REGULATIONS OF THE FISHERIES ON THE HIGH SEAS

By Charles Hugh Stevenson

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of two hundred dollars in gold offered by the Smithsonian Institution for the best treatise on international regulations of the fisheries on the high seas, their history, objects, and results

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DISCRIMINATION BETWEEN HIGH SEAS AND TERRITORIAL WATERS.

As used in defining the jurisdiction of admiralty courts, the term high seas implies all the waters of the ocean, and all connecting arms and bays, "exterior to low-water mark;" but in international law and in the sense employed in this paper, the term is not so broad, and it signifies only so much of the ocean as is outside the territorial jurisdiction of maritime states, and is what might be called the extraterritorial seas. It is now well established that the exclusive jurisdiction of a maritime nation covers only a narrow belt or margin of the littoral waters; beyond is the open ocean, the high seas, free to all for purposes of navigation and fishery, incapable of being monopolized by any state or people.

This principle in law is of relatively modern recognition. In the middle ages strong maritime powers made claims to sovereignty over considerable portions of the seas, which to some extent may have been justified by their maintenance of protection against piracy in those waters. At the height of her power the Republic of Venice was recognized as sovereign over the Adriatic Sea, and likewise Genoa over the Ligurian. France arrogated to herself a considerable stretch of the seas adjacent to her coasts. By his celebrated decision of arbitration on May 14, 1493, and by his approval of the treaty of Tordesilhas in the following year, Pope Alexander VI apportioned the Indian seas and the Pacific Ocean between Spain and Portugal. For three centuries Denmark claimed jurisdiction over the fisheries in the seas between Norway and Iceland; by treaties made in 1500 and 1523 this claim was acquiesced in by England, and English fishermen and traders in those waters were required to obtain licenses from the King of Denmark. With development in maritime strength, Great Britain claimed sovereignty over all the seas in communication with those surrounding her coasts, and in the seventeenth century fishermen of Holland and other countries were obliged to secure licenses from that Government, the Dutch in 1636 paying £30,000 for this purpose. Immediately previous to the Revolutionary war considerable portions of the Newfoundland banks and of the St. Lawrence Gulf were monopolized by Great Britain and her colonies, and at the conclusion of that war only the determined protest of the United States prevented the British Government from exercising jurisdiction thereover.

Although surrendered slowly and reluctantly, these extravagant claims of the great powers have given way to a just consideration of the rights of weaker nations. With development of commerce, the modern conception of the freedom of the seas, first formally set forth in 1609 by Grotius, that master builder in the science of international jurisprudence, was gradually established, and the limit of territoriality of a maritime state became restricted to a narrow margin surrounding her external seacoast. Within this limit the authority of a nation is paramount and exclusive, except as it may be affected by treaty rights and subject to peaceable passage by ships of other nations. Grotius, however, although restricting the authority of a maritime state to a limited distance seaward, gave only an indefinite idea as to the extent of this marginal belt, stating that it must be a reasonable area and bear a proper relation to the adjacent land.[a] Difference of opinion as to the precise limit has been great. Claims have been made now and again and by various authorities for 100 miles,[b] for 60 miles,[c] for two days' sail,[d] as far as the bottom can be found with the lead line,[e] and for as much as can be seen from the shore on a clear day.[f] Nearly one hundred years after the publication of Grotius's "Mare liberum," the learned yet practical Bynkershoek made the first statement of the present rule which defines the marginal waters as extending as far as the riparian state is able to exercise jurisdiction from the shore, the maxim in which this doctrine is tersely expressed being "Terræ finitur potestas ubi finitur armorum vis."[g] This seemed a just and practical solution of the controversy, and succeeding publicists adopted the attractive formula.

The modern conception of international law and the just relations and jurisdictions of nations had its birth and made its greatest progress in the seventeenth and eighteenth centuries, after the introduction of firearms and before the great development in modern artillery. Since authority over the marginal waters was exercised by means of cannon, it was natural to assume the distance of a cannon shot as the limit of jurisdiction. The extreme limit of cannon range being then about 3 marine or geographical miles, this distance from low-water mark became recognized as the extent of the marginal belt

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[a] De Jure Belli ac Pacis, II, ch. 3, sec. 3.

[b] Cœpolla, De servitutibus prœdiorum urbanorum, ch. XXVI, no. 14.

[c] Bodin, De Republicâ, lib. I, ch. X.

[d] Locenius, De Jure Maritimo, ch. IV, sec. 6.

[e] Valin, Commentaire sur l'Ordonnance de la Marine du mois d'aout 1681. Paris, 1761, ch. V, p. 687.

[f] Rayneval, Institution du Droit de la Nature et des Gens, lib. II, ch. IX, ch. X.

An old Scottish law recognized the jurisdiction of that country as extending seaward to the visible distance from the shore. Mackenzie calls attention to the grim sense of humor entertained by James V of Scotland (1513–1542): "In the time of K. James the 5th, the Hollanders having only a verbal licence to fish at 28 miles distance cam neere the shore into the mouth of the Furth of Edenborough, and ther fished in despight of the Kings comand. Then the King sent out men of warre and took so manie of them that he sent a barilful of their heads into Holland with their names fixed to their foreheads uppon cards." (MS. in Public Records Office. State Papers, vol. CLII, no. 63; quoted in Mackenzie's History of the Outer Hebrides, p. 304. Paisley, 1903.)

[g] Bynkerskoek, De Domino Maris, ch. II; Quæstionum Juris Publici, 1737, lib. I, ch. 8.

among those who preferred a distinct and uniform distance to a general and somewhat indefinite one. It was specifically acknowledged in the maritime regulations adopted by Tuscany in 1778, and in those of Genoa and of Venice in 1779; it was affirmed by Russia in 1787, by the United States in 1794, by Austria in 1803, and by various other nations at different dates. It was recognized in the convention of 1818 between Great Britain and the United States, in the fishery conventions between France and Great Britain of 1839 and 1867, in the convention of 1882 between Belgium, France, Denmark, Germany, Great Britain, and the Netherlands for the police of the fisheries in the North Sea, and in various other conventions, treaties, and arbitrations. Indeed, for many years the terms "maritime belt" and "the marine league" have been used interchangeably.

Objection to a universal recognition of the rule that territorial jurisdiction extends only 3 miles from land is made chiefly by Norway and Sweden. These states have never recognized the 3-mile limit as the confines of their territorial waters, and have never concluded nor acceded to any treaty setting forth that rule. By their municipal or national laws the limit has generally been fixed at 4 geographical miles. This was established in Norway by royal rescript of June 18, 1745, and has been affirmed repeatedly since then, especially in the early part of the last century.[a]

The Government of Spain has from time to time claimed exclusive jurisdiction within 6 nautical miles of her coasts and of those of her colonies. This claim was expressed in a royal cedula of December 17, 1774, which was supported by a royal decree of May 1, 1775, and by another of May 3, 1850, and was asserted as recently as August 4, 1874. But both Great Britain and the United States refused to accede to this pretension or to concede the extension of Spanish sovereignty beyond 3 littoral miles.[b]

Since harbors and small bays have more of the characteristics of territoriality than the open seas along the coast, it has been customary to recognize jurisdiction as extending over these within reasonable limits, even though they be not wholly within the 3-mile belt. But there is not at present any generally recognized standard as to what can be justly regarded as territorial bays when the width exceeds 2 marine leagues. Some authorities claim that the limit of exclusive jurisdiction is 3 miles from a line drawn from headland to headland,

[a] See p. 109 and 137.

[b] See letter of Lord Derby to Mr. Watson, December 25, 1874, Foreign Relations of the United States, 1875, p. 641, 649. In the language of Mr. Seward, it can not be admitted "that the mere assertion of a sovereign, by an act of legislation, however solemn, can have the effect to establish and fix its external maritime jurisdiction. This right to a jurisdiction of 3 miles is derived not from his own decree but from the law of nations, and exists even though he may never have proclaimed or asserted it by any decree or declaration whatsoever. He can not, by a mere decree, extend the limit and fix it at 6 miles because if he could, he could in the same manner, and upon motives of interest, ambition, or even upon caprice, fix it at 10, or 20, or 50 miles, without the consent or acquiescence of other powers which have a common right with himself in the freedom of all the oceans." (Letter to Mr. Tassara, Spanish minister, August 10, 1863.)

instead of a marine league from the shore following its sinuosities. The present tendency is to consider all bays less than 10 miles in width at the mouth as within the jurisdiction of the riparian state.

In the convention of 1839 between France and Great Britain, applicable to the seas lying between the coasts of the two countries, it was agreed that "the limits within which the general right of fishery is exclusively reserved to the subjects of the two kingdoms respectively are fixed (with the exception of those in Granville Bay) at three miles distance from low-water mark. With respect to bays the mouths of which do not exceed 10 miles in width, the 3-mile distance is measured from a straight line drawn from headland to headland." By a municipal law of June 7, 1832, Belgium had already adopted this rule.

The convention of 1882 signed by Belgium, Denmark, France, Germany, Great Britain, and the Netherlands, respecting the fisheries of the North Sea, recognized territorial waters as those "within the distance of 3 miles (geographical) from low-water mark along the whole extent of the coasts of their respective countries, as well as of the dependent islands and banks. As regards bays, the distance of 3 miles shall be measured from a straight line drawn across the bay, in the part nearest the entrance, at the first point where the width does not exceed 10 miles." And precisely the same language was used in the Anglo-Denmark convention of 1901 for regulating the fisheries in nonterritorial waters surrounding Iceland and the Faroe Islands.

The unratified Anglo-American fishery treaty of 1888 provided that the territorial jurisdiction of 3 marine miles "shall be measured seaward from low-water mark;" and after designating certain bays which should be considered as territorial waters, it set forth: "But at every bay, creek, or harbour not otherwise provided for in this treaty, such marine miles shall be measured seaward from a straight line drawn across the bay, creek, or harbour in the part nearest the entrance at the first point where the width does not exceed 10 marine miles."

While the tendency of international law is to restrict jurisdiction over large coastal indentations, there is no absolute rule in this respect. Chesapeake Bay and likewise Delaware Bay are recognized as parts of the territory of the United States.[a] Great Britain claims territorial jurisdiction over Conception Bay in Newfoundland,[b] which is of an average width of 15 miles; also over Bristol Channel,[c] an arm of the sea about 80 miles long and from 5 to 45 miles wide.[d] France claims the Bay of Cancale, which is 17 miles wide, and also a large portion of Granville Bay. Other territorial bays in Europe are: White Sea in Russia, Zuider Zee in Holland, and the Frisches Haff, the Kurisches Haff, Bay of Stettin,

[a] Wharton, Digest of International Law, 2d ed., sec. 27 and 28.

[b] Direct United States Cable Company *v.* Anglo-American Telegraph Company (1877), L. R. 11 App. Cases, 394.

[c] Queen *v.* Cunningham (1859), Bell's Crown Cases, 86.

[d] See also page 136, with reference to her claim of jurisdiction over Moray Firth, which is about 85 miles across at the mouth.

and Jade Bay in Germany. Norway claims as territorial waters many of her great fiords or gulfs, which are very wide at the mouth and extend far inland; and she especially reserves to her fishermen the very important cod fishery prosecuted by 30,000 men each spring in West Fiord and about the Lofoten Islands, this exclusive right being founded in immemorial usage.

The situation was well expressed by Lord Blackburn in 1877 in the case involving jurisdiction in Conception Bay: "It does not appear that jurists and text writers are agreed what are the rules as to dimensions and configurations which, apart from other considerations, would lead to the conclusion that a bay is or is not a part of the territory of the state possessing the adjoining coasts; and it has never been made the ground of any judicial determination." The question has to be considered in each case with regard to international laws and usages affecting that particular body of water; but nations are inclined to view with jealousy this extension of territoriality, and the burden of establishing the usage is upon the nation claiming under it.

While the Supreme Court of the United States has held[a] that the waters of the Great Lakes are "high seas" within the meaning of a certain section of the criminal laws,[b] yet those waters are not high seas as the term is used in international law and in this paper. The Great Lakes are wholly territorial, and the waters on either side of the international boundary line are under the exclusive jurisdiction of the respective countries.

RESTRICTION OF FISHERIES ON THE HIGH SEAS.

Although it is customary to speak of the "freedom of the seas," we must not understand that this signifies lawlessness. The freedom of the seas simply implies perfect freedom of navigation and fishery for vessels of all nations without restriction from any foreign government. As regards the vessels flying its flag, each sovereign state has as much authority on the high seas as within its territorial waters, and may enforce among them any regulations or restrictions it may deem advisable. Consequently the municipal law of a power is sufficient for regulating those fisheries on the high seas prosecuted only by subjects of that nation. Prominent instances of the exercise of this authority are found in the old herring regulations of England and of Scotland, in the Newfoundland seal-fishery laws of 1879 and 1892, the American mackerel law of 1887, the Australian pearl-shell regulations of 1888 and 1889,[c] and in regulations established by many of the continental countries. Although these municipal laws are operative on the high seas, they are not international regulations, which signifies something more than the independent legislation of an individual state, affecting its subjects only.

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[a] United States *v.* Rogers (1893), United States Reports, vol. 150, p. 249.

[b] Section 5346 of the Revised Statutes, giving the federal courts jurisdiction over certain crimes committed upon American vessels "on the high seas and out of the jurisdiction of any particular state."

[c] The municipal regulations for the pearl fisheries of the colony of Western Australia extend over an area of the high seas estimated at 700,000 square miles.

In relation to the subjects of another sovereign power the situation is quite different, for no single nation is allowed to interfere on the high seas with the vessels of another nation without previous agreement. Indeed, so liberally does international law guard the coast fishermen that even in war they are humanely exempted from capture while engaged in their legitimate pursuit. And a municipal law has no effect on the high seas except on the vessels flying the flag of that particular nation.

Where vessels of several powers are concerned, it is a hardship and exceedingly unjust for one government to enforce restrictive regulations among its own fishermen without concurrent action by other governments, for this makes a hurtful monopoly in favor of foreigners. The principal effect of such action is usually to transfer the nationality of the operations from the government enforcing the restriction to one under which greater freedom is enjoyed. Striking instances of this may be found in the transfer of pelagic fur-sealing vessels from the American to the British flag when the United States interdicted pelagic fur sealing in 1886, and also in their transfer to the Japanese flag after both America and England agreed upon the Bering Sea regulations in 1893. By united action of all the nations interested in a particular fishery, however, regulations may be established and enforced on the high seas as effectively as though that fishery were prosecuted within territorial waters. Hence arises the importance of concurrent action among the powers interested when such regulations are found necessary, and such action is obtained through international conventions and agreements. These conventions recognize the right of all nations to fish in the seas beyond the territorial waters, but for their mutual benefit each one agrees to restrict its own subjects by regulations to be observed by all alike. Such regulations do not apply to the subjects of nations which are not parties to the agreement and do not restrict their fishing in any place or in any manner.

The number of instances in which nations have united or even concurred in regulating fisheries on the high seas is not large. Fortunately for the length of our paper, the much discussed "fisheries question," respecting the rights and privileges of the British provinces and of the United States on the northeastern coast of America, does not relate to the high seas, although it bears materially on the limit of maritime jurisdiction.

The first prominent attempt at international regulation of the fisheries was the Anglo-French convention of 1839, applicable to the English Channel and adjacent seas, which set forth the limits of exclusive jurisdiction in marginal waters and established regulations for preserving the oyster and other fisheries and for maintaining order among the fishermen. The regulations prepared in 1843 in accordance with the provisions of this convention were never satisfactory and have been of little effect. In 1867 an effort was made to revise them, and a convention was signed to this effect by representatives of the two nations; but this failed, owing to lack of confirmation by the French Government.

The North Sea convention of 1882, among Belgium, Denmark, France, Germany, Great Britain, and the Netherlands, was strictly for the police of the

fisheries and to prevent the destruction of property. As determined by the results accomplished, this is doubtless the most important of all international fishery regulations. In 1901 Denmark and Great Britain applied the provisions of this convention to their fisheries in the waters surrounding Iceland and the Faroe Islands.

The submarine cable convention of 1884 interdicted fishing in the vicinity of cables and cable ships. Strictly speaking, this has never interfered materially with fishery operations, but the convention is important in that the restriction on the fisheries has been agreed to by nearly every important nation.

The convention of 1899 between Sweden and Denmark authorized the subjects of each of these nations to fish in certain territorial waters of the other and also provided against the destruction of fishing gear operated in the waters between the two countries. In 1907 this convention was supplemented by a declaration that plaice under a designated length should not be caught or landed from the waters of the Cattegat or The Sound.

In all of the conventions noted the interests of the signatory powers were fairly mutual and the restrictions bore evenly on the subjects of the several nationalities. But in 1893 an international agreement occurred which was unique in that the interests of the powers were in absolute conflict. This was the Bering Sea arbitration between Great Britain and the United States, which was intended to restrict the scope of the pelagic fur-seal fishery, prosecuted almost exclusively by subjects of Great Britain, with a consequent and corresponding advantage in the yield on the Pribilof Islands, under the exclusive jurisdiction of the United States. Although the practical results of the regulations established by that tribunal of arbitration have been far short of what was expected, from the standpoint of international law this is the most important of all fishery agreements applicable on the high seas, owing to the numerous and lengthy arguments presented in the tribunal and the influence of their decision.

From the foregoing it appears then that the international fishery regulations operative on the high seas have been of two general classes, the one for preserving the resources and the other for the maintenance of good order among the fishermen and for preventing the destruction of property. To the former class belong the Bering Sea fur-seal regulations, and in some particulars the Anglo-French regulations of 1843, and the declaration of 1907 between Sweden and Denmark. All the remaining conventions and regulations are of the second class.

Aside from the submarine cable convention of 1884, which was confirmed by nearly every important nation, it appears that as regards the number of sovereign powers adhering to it, the North Sea convention of 1882 was the most general of all these international regulations, having received confirmation from Great Britain, France, Germany, Belgium, Denmark, and the Netherlands. Each of the remaining conventions and regulations applied to the subjects of

two governments only, of which in four instances Great Britain was one of the parties. Thus it appears that in the six important instances of international regulation or restriction of the fisheries on the high seas, Great Britain has been actively concerned in five; Denmark in four; France in three; Germany, Belgium, the Netherlands, and the United States each in two; and Sweden in one of them. The Greenland seal fishery restrictions of 1875–1877, enacted by Denmark, Great Britain, the Netherlands, Norway, and Sweden, differ from international regulations in that they were not the result of a formal convention or agreement, but were based on analogous municipal enactments by these powers acting in concert. These restrictions were for the purpose of preventing the exhaustion of the seal herds in the waters about Jan Mayen Island and off the eastern coast of Greenland, a purpose which they have failed signally in accomplishing. Each of these conventions, agreements, and regulations will be considered separately.[a]

[a] In addition to the international agreements respecting the fisheries on the high seas, there have been very many treaties, conventions, declarations, etc., for regulating those prosecuted in territorial waters on the frontiers of bordering states, of which the following is only a partial list:

1839, April 19. Belgium and the Netherlands (article 9).
1840, April 5. France and the Grand Duchy of Baden.
1843, May 20. Belgium and the Netherlands, for the enforcement of article 9 of the convention of April 19, 1839.
1849, February 9. Prussia and the Grand Duchy of Luxemburg.
1856, December 2. France and Spain, respecting the fisheries in the Bidassoa River (abrogated).
1866, May 26. France and Spain, respecting the fisheries in the frontier rivers (Nive, Garonne, Signe, etc.).
1880, December 28. France and Switzerland, respecting the fisheries in the frontier waters.
1882, April 19. Belgium and the Grand Duchy of Luxemburg.
1882, May 6. Belgium and the Netherlands.
1882, November 8. Italy and Switzerland, on the fisheries in the bordering waters.
1883, August 9. Austria-Hungary and Italy, regulating the fishery in Lake Garda.
1884, April 3. Belgium and the Netherlands, modifying the regulations of May 20, 1843.
1885, June 30. Germany, Switzerland, and the Netherlands, for regulating the salmon fishery in the Rhine.
1886, February 18. France and Spain, respecting the fishery in Bidassoa River (modified January 19, 1886; September 20, 1888; October 4, 1894; and December 17, 1898).
1887, May 18. Switzerland, the Grand Duchy of Baden, and Alsace-Lorraine, respecting fisheries in the Rhine and its tributaries, including Lake Constance.
1891, March 12. France and Switzerland, concerning fisheries in the frontier waters.
1891, July 30. France and Switzerland, supplementary to the convention of December 28, 1880, respecting fisheries in the frontier waters.
1892, November 5. Prussia and the Grand Duchy of Luxemburg.
1893, July 5. Switzerland and the Grand Duchy of Baden, respecting the fisheries in Lake Constance.
1894, September 25. Switzerland and Baden, supplementary to the convention of July 5, 1893, respecting the fisheries in Lake Constance.
1897, July 3. Switzerland and Baden, concerning the fisheries in lower Lake Constance.
1898, July 8. Italy and Switzerland, concerning uniform regulations for the fisheries in the bordering waters.
1899, December 27. France and Switzerland, regulating the fisheries in the frontier waters.
1900, June 23. Russia and Roumania, respecting the fisheries in the River Pruth and in the lower Danube.

ANGLO-FRENCH CONVENTION OF 1839.

The first successful attempt at international concert in regulating the fisheries on any part of the high seas resulted in the convention of August 2, 1839, between France and Great Britain, which applied to "the seas lying between the coasts of the two countries." This convention had its origin in the many disputes which had arisen with respect to the limits in which the subjects of each of the two kingdoms were permitted to fish, and especially in contentions which arose in 1837 and 1838 between French fishermen and those of the channel islands. The principal objects of this convention were stated to be: (1) To define the limits of territorial jurisdiction and exclusive fishery over the marginal waters of the two countries; (2) to provide regulations for preventing collisions among fishermen in the seas lying between the coasts of Great Britain and France; and (3) to settle the limits of the oyster fisheries lying between the Channel Islands and France.

By the ninth article of this convention, the right of fishing within 3 miles from low-water mark along the coasts of each country, respectively, was exclusively reserved to the subjects of that country; and in bays not more than 10 miles in width, the distance of 3 miles was measured from a straight line connecting the two headlands. The first of these provisions was in strict accordance with international law as then recognized. The second provision was novel, but a practical reason suggested it. It was considered that as 3 miles on each side of a bay less than 10 miles in width were unquestionably territorial, the interests of the proprietary nation within the bay were sufficient to determine its territoriality. This is by far the most important and lasting of all the provisions of the convention.

The eleventh article provided that with a view to preventing collisions which had occurred so frequently between the fishermen of France and those of Great Britain on the seas lying between the two countries, and to carry out other purposes of the convention, a commission should be appointed to prepare a set of regulations for guidance of those fishermen in the seas above noted.

In pursuance of the provisions of this article and of the convention generally, a code of regulations was prepared and confirmed by the respective Governments in June, 1843. The 89 articles agreed upon embrace many other subjects than those contemplated by the convention, and they constitute by far the most elaborate and complicated of all fishery laws applied to any part of the high seas. They are given in full in Appendix A (page 151 of this paper), and in this place we have room for only a brief résumé.

Articles 1 to 5 of the regulations define the limits within which the right of fishery is exclusively reserved to the subjects of the two countries, respectively. Articles 6 to 15 provide for the numbering, lettering, and licensing of all British and French fishing boats, and for the numbering and lettering of all buoys, floats, nets, and other implements of fishery. Articles 16 to 26 regulate

trawl fishing, defining the size of mesh, the length of beam, the weights of head-pieces and of ground rope, and the distance trawlers may fish from boats engaged in drift netting for herring or mackerel. Articles 27 to 35 regulate the herring fishery, defining the size of mesh in nets, the manner of shooting the nets by decked and undecked boats, respectively, and the distance at which these boats should remain apart when fishing. Articles 36 to 40 regulate the mackerel fishery in a manner somewhat similar to the preceding articles. Articles 41 to 44 regulate the fishing with bratt nets, trammel nets, and other set or anchored nets. Articles 45 to 49 regulate oyster fishing, establishing close time from May 1 to August 31, and from sunset to sunrise in the remaining months, and requiring the fishermen to throw back on the reefs all oysters measuring less than 2½ inches in length, and also all gravel, shell fragments, etc. Articles 50 to 54 define the flags, lights, and signals to be displayed by fishing boats. Articles 55 to 60 supplement several of the foregoing provisions respecting size of mesh in nets and noninterference with nets belonging to other fishermen. Articles 61 and 62 relate to the salvage of fishing boats, nets, gear, etc. Articles 63 to 75 provide means for enforcing these regulations by the cruisers and agents of the two countries, the summary proceedings before magistrates, and the fines and penalties that may be imposed. Articles 76 to 86 define the conditions and circumstances under which the fishing boats of either of the two countries are at liberty to come within the territorial limits of the other country. Article 87 forbids the shooting of herring nets earlier than half an hour before sunset, except where it is customary to carry on this drift-net fishing by daylight. Article 88 deals with fishing on the Sabbath day "within the fishery limits of either country." Sunday fishing outside of these limits was not prohibited by these regulations, and as the fifth article interdicted the subjects of one country from fishing within the limits of another country at any time, the purpose of this article is not clear. Article 89 authorizes the commanders of the cruisers and also all fishery officers of each of the two countries to enforce the above regulations.

These regulations were enacted into law in Great Britain (6 and 7 Vict., ch. 79), dated August 22, 1843, and in France by royal ordinance of June 27, 1846.

It is generally admitted that the terms of the convention of 1839, of the pursuant regulations of 1843, and of the legislative enactments adopted in connection therewith were defective and ambiguous. Owing to difference of opinion as to the limits in which they were applicable, as well as to their severe conflict with the fishery laws then operative in British territorial waters (Geo. I, ch. 18), the convention regulations were never enforced. It was claimed by some authorities that the words "the seas lying between the coasts of Great Britain and of France" should be construed strictly, and referred only to the English Channel; but it was held by others—and probably with greater reason—that this phrase comprised all the seas about the British coasts, including those off the eastern and even the northern coast of Scotland. And many of the

provisions respecting the modes and the times of shooting the drift nets, and the construction details of trawls, etc., would have been either futile or mischievous had they been enforced.

Some attempt was made to enforce the provisions relating to the numbering of fishing boats, and cruisers were occasionally sent among them to preserve order; but there was no serious attempt to enforce such regulations of the fisheries themselves as did not meet with the wishes and conveniences of the fishermen, except with respect to territorial limits and to the close season in the English Channel oyster fishery, the regulations of which were enforced for several years following 1852, at the instance of the French Government.

In 1866 the commissioners appointed to inquire into the sea fisheries of the United Kingdom reported respecting the convention act of 1843:

> It is obvious that the majority of its regulations, so far as they affect methods of fishery and not matters of police, are either superfluous or impracticable or injurious, their evil tendencies being only neutralized by the circumstance that they are disregarded. And even were the provisions of the act requisite or expedient, the highest legal authorities are so completely at variance concerning the interpretation and the limits of the application of the act, that it must be regarded as an extremely defective piece of legislation.[a]

For the purpose of revising the convention of 1839 and the regulations of 1843, a new convention was signed at Paris on November 11, 1867. It applied beyond the territorial waters of both countries, "to the seas surrounding and adjoining Great Britain and Ireland, and adjoining the coast of France between the frontiers of Belgium and Spain."

The details of this convention were more definite and much less complicated than the regulations prepared in accordance with the convention of 1839. Instead of 89 articles there were only 42. The principal changes were removal of all restriction on the size of mesh and on the forms and construction of beam trawls, etc., and an extension in the termination of the oyster season from April 30 to June 15. Also an improvement was attempted in general supervision and in methods of enforcing the regulations governing the conduct of the fishermen. The articles of this convention are given in full in Appendix B (page 158 of this paper).

To carry into effect the provisions of the convention of 1867 was the principal intention of the British sea fisheries act of 1868 (31 and 32 Vict., ch. 45), which repealed the convention act of 1843. Reciprocal action in France failed, however, and the provisions of the new convention were never made applicable to French boats and fishermen. And the convention act of 1843 having been repealed by the sea fisheries act of 1868 (sec. 71), there was an absence of mutual regulations until 1877, when the provisions of the convention act of 1843 were revived by the fisheries act of 1877 (40 and 41 Vict., ch. 42, sec. 15) so far as regards French fishermen, "until the day when the convention of 1867 might be brought into operation by action of the French Government."

[a] Report of the commissioners, p. LXXIV.

As a result of this legislative condition, while the provisions of the convention of 1867 were enforceable against British subjects by virtue of the act of 1868, it was necessary, when dealing with the offenses of French fishermen, to have recourse to the regulations drawn up in 1843 under the convention of 1839. Naturally this caused much confusion, and the British sea fisheries act of 1883 (46 and 47 Vict., ch. 22) repealed the convention act of 1868, so far as the same had come into force, with the exception of certain specified sections and articles, especially those relating to the numbering and lettering of fishing boats.

Since 1883 the provisions of the North Sea convention of 1882[a] have within the limits of the North Sea superseded the regulations of 1843; while outside the North Sea and the British exclusive limits, most of the regulations of 1843 are regarded as obsolete and are rarely enforced, and they have little effect on the fisheries at the present time. It was thought that the success of the North Sea convention of 1882 would speedily result in the application of its provisions to the Channel fisheries also, but nothing has yet been done in this direction.

The British "Manual for the Guidance of Officers Connected with the Sea Fisheries" states that while articles 24–26, 29, 33, 52, and 57–59 of the regulations of 1843 now apply to French boats outside the exclusive fishery limits in the seas between Great Britain and France, "it must be distinctly understood that none of the regulations of 1843 which relate to the size of the mesh of nets, the close time for fish other than oysters, or to matters which are repugnant to the spirit of the North Sea Fisheries Convention, are to be enforced."[b]

THE NORTH SEA CONVENTION OF 1882.

The most important fishery region of the world is the North Sea, situated east of England and Scotland, north of Belgium, the Netherlands and Germany, and west of Denmark and Norway. Within its waters, covering about 150,000 square miles and averaging less than 50 fathoms in depth, about 1,500,000,000 pounds of fish are taken annually, which is far more than the total weight of all the food fish taken on all the coasts and lakes and rivers of the United States. Upon these waters are employed thousands of fishermen from the adjoining countries.

During the latter half of the nineteenth century extremely unsatisfactory police conditions developed in the fisheries of the North Sea. With thousands of vessels fishing in relatively limited areas, much confusion arose, fishing gear was carelessly fouled, and in many instances nets were wantonly destroyed as the easiest method of freeing them, a special implement being provided for this purpose.[c] There was no uniformity in the display of lights and in marking

[a] See p. 116–121 of this paper.

[b] Edition of 1903, p. 9, sec. 23.

[c] An implement known as a "devil" had been employed for several years, especially, it is said, by the Belgian fishermen. Its manufacture, sale and use were interdicted by a municipal law of Belgium dated March 27, 1882.

Map showing area delimited by the North Sea Convention of 1882.

vessels for identification. And there was an absence of regulations for preventing collisions between vessels working in close proximity to each other.

For the purpose of remedying these unsatisfactory conditions and for policing the fisheries outside territorial waters, there was a conference of the interested Governments at The Hague in 1881 and again in 1882, to discuss provisions for joint regulations. This resulted in a convention signed on May 6, 1882, by delegates from Belgium, Denmark, France, Germany, Great Britain, and the Netherlands, power being reserved for adherence by Norway and Sweden. This is doubtless the most important document ever drawn up in connection with international police of the fisheries.

The principal stipulations of this convention are as follows:[a] Article 1 restricts the provisions of the convention to subjects of the contracting parties. Articles 2 to 4 define the limits of territorial jurisdiction and the limits of the North Sea for the purposes of the convention. Articles 5 to 13 provide rules for registering, numbering, and lettering vessels for identification, and the marking of small boats, nets, etc. All the fishing vessels must be registered and the registers are exchanged between the powers; every vessel bears in white oil color on black ground its name, number, and the initial of its harbor, and likewise carries an official voucher of its nationality. Articles 14 to 24 provide minute restrictions on fishermen in the conduct of their various operations so as to avoid collisions and to prevent injury to the nets and other apparatus. Article 25 refers to the salvage of fishing vessels, boats, nets, lines, etc. Articles 26 to 37 relate to the supervision of the fisheries by cruisers of the different nations and to the prosecution of offenses against the convention. The executing of regulations respecting documents, marking boats and equipment, and the use of interdicted implements was placed under the exclusive superintendence of the cruisers of the nation of each fishing boat; but cruisers of any one of several nations were made competent to authenticate all infractions of the regulations other than these. For this purpose they have the right to visit, search, and arrest; but a seized vessel must be conveyed to a harbor of her flag state and turned over to the authorities there. All violations are to be tried by the courts of the state to which the contravening vessels belong; but cases of minor damage may be arbitrated at sea by the commanders of the cruisers should the parties concerned agree to it. This superintendence by cruisers is authorized only in respect to boats belonging to nations which are parties to the convention, and only when such boats are within the North Sea as defined by the convention. Articles 38 to 39 provide that the convention shall be ratified, and shall continue in operation until one of the powers gives notice of intention to terminate it; and in that event the convention shall be maintained among the other powers unless they give a similar notice.

[a] The articles are given in full in Appendix C (page 163 of this paper). The matter is treated in great detail by Hacke, Einige Opmerkingen over het Politietoezicht op Zee, in verband met de Zeevisscherij-Conventie van 6 Mei 1882, Amsterdam, 1885; and by Rykere, Le régime légal de la pêche maritime dans la Mer de Nord, Paris, 1901.

Each of the interested Governments enacted legislation for enforcing the provisions of this convention, the laws being promulgated by the respective states on the following dates: In Great Britain, August 2, 1883; in the Netherands, December 7, 1883; in Belgium, January 6 and 8, 1884; in France, January 15 and April 5, 1884; in Denmark, March 29, 1884, and in Germany, April 30, 1884. The regulations of the convention came into force on May 15, 1884.

Although an additional article made provision for adherence to the convention by Norway and Sweden, either jointly or separately, neither of these nations has assented, and they are not bound thereby. Nor has any one of the signatory powers withdrawn; so that the regulations of the convention are yet operative among them.

In 1891 the Governments of Great Britain and Belgium united in a declaration for the purpose of simplifying the procedure for the settlement of differences between British and Belgian fishermen in the North Sea outside territorial waters, and of reducing as much as possible the injuries they may sustain from the fouling of fishing gear. This declaration is given at length in Appendix D (page 167 of this paper). It was confirmed in Great Britain on July 21, 1891 (54 and 55 Vict., ch. 37), and in Belgium on August 19, 1891.

Difficulties among the fishermen in the North Sea decreased as a result of the convention of 1882, especially with the better understanding of that convention and of the laws founded upon it, although cases still occur in which avoidable injury is occasioned to the gear. The following summary shows for a series of years the number of complaints made against foreigners by British fishermen, with the amount of damages claimed and the amount of damages collected, and similar data relative to foreign complaints made against British fishermen. This probably represents fully three-fourths of the total number of complaints made during the years herein reported.

SUMMARY SHOWING FOR A SERIES OF YEARS THE NUMBER OF COMPLAINTS, AMOUNT OF DAMAGES CLAIMED AND THE AMOUNT OF DAMAGES COLLECTED, BY AND AGAINST BRITISH FISHERMEN UNDER THE NORTH SEA CONVENTION OF 1882.

Year.	Complaints against foreigners by British fishermen.			Complaints against British by foreign fishermen.		
	Number.	Damages claimed.	Damages collected.	Number.	Damages claimed.	Damages collected.
		£	£		£	£
1891	12	318	13	11	2,212	57
1892	9	280	143	16	310	53
1893	10	229	65	20	513	74
1894	12	115	102	24	330	40
1895	4	208	98	14	416	33
1896	4	41	6	9	162	----------
1897	5	212	95	12	159	54
1898	18	696	158	13	106	----------
1899	9	372	----------	8	273	169
1900	14	943	701	8	253	18
1901	10	304	93	10	727	5
1902	5	484	442	9	275	65

The greater size of steam trawlers, the improvements in the apparatus of capture, and the increased use of ice in preserving the catch, have resulted in extending trawling operations not only to all the available waters in western Europe, but to those of Iceland, northern Europe, and even to the coast of Africa. The increased receipts have been especially noticeable from Iceland, Faroe, and the Bay of Biscay. Throughout the whole of this region the area within a depth of 100 fathoms is now exploited, and the fishermen of several nationalities meet there on a common footing; but the regulations of the convention of 1882 apply to no other region than the North Sea.

Not a regulation of the fisheries themselves, but having an important bearing thereon, is the abolition of the liquor traffic among the fishing vessels in the North Sea. Trading boats from England, Germany, and the Netherlands were especially fitted out two or three decades ago for traffic among the fishing fleet, supplying the cheapest of liquors, tobacco, and obscene cards and literature. Dreadful evils resulted from this "bumboat" trade. The question of its regulation or abolishment was discussed at The Hague conference in 1881 which resulted in the North Sea convention of 1882, but without effect. After numerous unsuccessful attempts at regulation, an international convention was entered into on November 16, 1887, by representatives of the signatory powers of the 1882 convention, binding them to effect such legislation as would entirely prohibit the sale, exchange, or barter of spirituous liquors—that is, liquids "obtained by distillation and containing more than 5 per centum of alcohol"—and would establish a system of licensing bumboats for traffic with persons on board or belonging to fishing vessels of those nationalities in the North Sea outside territorial waters.

Failure on the part of France to ratify the convention nullified its conclusions.[a] However, on February 14, 1893, the other signatory powers, viz, Belgium, Denmark, Germany, Great Britain, and the Netherlands, entered into a protocol by which they agreed to bring the convention into force so far as their own boats and subjects were concerned, when such boats or subjects are outside territorial waters and within the limits of the North Sea, as defined by article 4 of the 1882 convention. Each licensed boat is required to exhibit, from the head of the principal mast, a white flag 2 meters square, bearing in the center the letter "S" in black, 1 meter high and 2 decimeters wide. Acts of legislature passed by each of these powers came into force on May 23, 1894. Since that date traffic in liquor by their subjects in the North Sea has been illegal, and in the same waters provisions and other articles for use by fishermen

[a] It is but just to add that this nonaction on the part of France was not due to sympathy with the traffic, for it has not been represented that boats of that nation have ever engaged therein. It was because of the opinion that the regulations were contrary to the fundamental principles of the freedom of commerce and the view that the municipal laws of the offending nations would suffice to end the traffic.

may be sold only by persons licensed by the respective Governments.[a] The enforcement of these regulations is referred to the same officials who are charged with the police of the fisheries in the North Sea, with the proviso that the regulations do not in any way affect French fishermen or concern French cruisers.

ANGLO-DENMARK CONVENTION OF 1901.

The success of the North Sea convention of 1882 resulted in similar action by Great Britain and Denmark for regulating the police of the fisheries prosecuted by their subjects outside territorial waters about Iceland and the Faroe Islands. A convention between these two powers was signed at London on June 24, 1901, and ratifications were exchanged on May 28 in the year following. This convention and the regulations established thereunder applied to about 230,000 square miles (geographical) of water area outside the territorial jurisdiction of Denmark about Iceland and the Faroe Islands, constituting the largest definite area in which an attempt has been made to police the fisheries by international convention.[b]

In detail the provisions of this convention were almost literally the same as those of the North Sea convention concluded at The Hague in 1882. Each article followed the older convention almost word for word, except in article 4, defining the geographical limits to which they applied, and in article 8, which contained the additional provision that steam fishing vessels should be appropriately marked on the funnel. Since the convention of 1882 there had been a very large increase in the number of steamers employed in the trawl fisheries, and most of the English vessels fishing about Iceland were of this type, hence the importance of this item. As in all other international fishery conventions, the courts of the flag state of the infringing vessel were made exclusively competent to deal with infractions of the regulations, but cruisers of either of the signatory powers were authorized to search and arrest. An additional article stipulated that any other Government, whose subjects fish in the seas surrounding Iceland and the Faroe Islands, may adhere to this convention; but no nation has yet availed itself of this privilege.[c]

The geographical limits for the application of this convention were fixed as follows: "On the south by a line commencing from where the meridian of North Unst light-house (Shetland Islands) meets the parallel of sixty-first degree of north latitude to a point where the ninth meridian of west longitude meets the parallel of 60° north latitude, and from thence westward

[a] For a more extended discussion of these regulations, see Guillaume in Revue de Droit International et de Législation Comparée, t. xxvi (1894), p. 488.

[b] The dominion of the North Sea convention of 1882 approximated 150,000 square miles. The concurrent municipal laws of 1875–1877 regulating the Jan Mayen seal fishery (see p. 135) applied to about 285,000 square miles.

[c] The articles of this convention are given in full in Appendix F (page 169 of this paper).

along that parallel to the meridian of 27° west longitude. On the west by the meridian of 27° west longitude. On the north by the parallel of 67° 30′ of north latitude. On the east by the meridian of the North Unst light-house." (Article IV.)

SUBMARINE CABLE CONVENTION OF 1884.

Another restriction of the fisheries on the high seas is a result of the convention for protecting submarine telegraph cables.

As early as 1869 the United States Government suggested a conference at Washington for consideration of this subject, but the Franco-Prussian war prevented the proposed convention. Various meetings were subsequently held at Rome, Brussels, and Paris, and an "International Convention for the Protection of Submarine Cables" was finally concluded and signed by the representatives of 25 sovereign powers at Paris, on March 14, 1884. The ratifications of 17 of these states were exchanged at Paris on April 16, 1885, and the convention was proclaimed on May 22 of the same year.

While the submarine cable regulations have not seriously interfered with fishing operations in any single region, the convention is noteworthy in this connection because of the very large number of sovereign states which adhered to it, including nearly every important nation in the world outside Asia, and even that continent was represented by Turkey, and Japan acceded to it some years later, so that the dominion of this convention now extends almost as far as civilization. Indeed, since those powers which have not signed the convention have not acted in opposition to it, one might safely maintain that these regulations have almost become universal international law through custom.

The terms of this convention are applicable outside the territorial waters, and they provide among other things that willful and unnecessary injury to a submarine cable shall be a punishable offense. Vessels, fishing gear, and nets shall be kept at the distance of at least 1 nautical mile from a vessel flying signals that she is engaged in laying or repairing a cable; "nevertheless, a period of twenty-four hours at most shall be allowed to fishing vessels that perceive or are able to perceive a telegraph ship carrying the said signals, in order that they may be enabled to obey the notice thus given, and no obstacle shall be placed in the way of their operations during such period." Vessels, nets, and gear must be kept at the distance of at least one-quarter of a nautical mile from buoys designed to show the position of cables when the latter are being laid, are out of order, or are broken. And owners of vessels who can prove the sacrifice of an anchor, a net, or any other implement used in fishing, in order to avoid injuring a cable, shall be indemnified by the owner of the cable, upon sufficient proof made promptly to the competent authorities.[a]

[a] The articles of this convention which relate to the fisheries are given in full in Appendix E (page 168 of this paper).

Map showing territory covered by the Anglo-Denmark Convention of 1901.

A final protocol, signed at Paris, July 7, 1887, fixed upon May 1, 1888, as the date upon which the instrument was to become finally operative. This was ratified by the United States on May 1, 1888, suitable provision for its enforcement having been already made by act of February 29, 1888 (25 Stat. L., p. 41). Practically all the other parties to the convention have enacted appropriate legislation for enforcing the regulations. And while these have safeguarded the property of the cable companies and the freedom of telegraphic communication, they have not imposed special hardship upon the fishermen or restricted their operations in any noteworthy degree.

REGULATIONS OF THE FUR-SEAL FISHERIES.

No attempt at regulating or restricting any branch of the fisheries on the high seas has caused more extended discussion or is more interesting from the point of view of this paper than the protection which the American and the Russian Governments have endeavored to give to the fur seals outside territorial jurisdiction in the North Pacific Ocean and tributary waters.

The well-known breeding habits of this animal, and its resort to the same shores year after year, render its capture on the rookeries an easy matter. This resulted in the slaughter of millions of them a century ago and nearly exterminated the species in the southern seas. But on the Pribilof Islands, the great breeding grounds of the northern fur-seal herd, the Russian Government about 1840 developed a system of management which tended to the greatest utilization with the least injury to the perpetuation of the resource. The keynote of this system was the absolute protection of the females, none whatever being intentionally slaughtered, and the killing was confined to the young males 2 or 3 years old, 95 per cent of which are superfluous for breeding purposes, owing to the polygamous habits of the animal. Grouped by themselves on the rookeries, the young males are surrounded, and those selected for slaughter are slowly driven off, precisely as one would drive a flock of sheep.

Under this wise system of management the herd prospered, and contained probably 3,000,000 or 4,000,000 animals when the Pribilof Islands came into the possession of the United States with the transfer of Alaska under the convention of March 30, 1867.

The act of July 27, 1868, by which the territory was erected into a customs district, made it the duty of the Secretary of the Treasury "to prevent the killing of any fur seal," except as it should be otherwise provided by law. By act of July 1, 1870, it was made "unlawful to kill any fur seal upon the islands of St. Paul and St. George, and in the waters adjacent thereto, except during the months of June, July, September, and October," or "to kill such seals at any time by the use of firearms, or use other means tending to drive the seals away from the said islands." And in August of the same year the Government leased the privilege of taking fur seals on the Pribilof Islands to a corporation

organized under the laws of California, the take being fixed at 100,000 young males annually, under the system of management developed by the Russian Government.

From time immemorial the Indians of the northwest coast had been accustomed to capture the fur seals in the open sea, as these animals passed along the coast en route to and from the breeding grounds, spearing males and females indiscriminately as they were found sleeping at the surface of the water. The extent of this slaughter was small, probably never exceeding 6,000 or 7,000 in any one year previous to 1879, and it is generally agreed that it had no serious effect in diminishing the herd.

But the high value of fur-seal pelts about thirty years ago induced persons to fit out vessels for conveying a number of Indians and their canoes to the main path of the migrating animals and there follow them day after day, so as to prosecute their capture with greater effect. About 1881 this pelagic fleet extended its operations to Bering Sea, where it met with so much success that the number of vessels quickly increased to 34 in 1886, to 68 in 1889, and to 115 in 1891, each with from 5 to 20 canoes. The number of fur seals taken by these vessels reached the total of 59,568 in 1891, valued at about $938,196, all of which were taken by Canadian fishermen, as the law of 1868 was enforced against American subjects. In the meantime the American lessees on the Pribilof Islands were obliged by reason of the decreased size of the herd to reduce their take from an annual average of 100,000 pelts previous to 1886 to 12,040 in 1891, valued at about $360,000. There was a large preponderance of females among the animals taken in the pelagic fishery, owing to the slaughter of surplus males on land, the proportion being about 4 females to 1 male. The capture of a female in the spring migration to the rookeries involved the death of her unborn offspring, and the killing of the mother in August or September resulted in the death of her dependent young on the islands.

Rather than witness the destruction of this valuable resource, the American authorities in 1886 construed the aforementioned acts of 1868 and 1870 as applicable to the entire water area within the limits of territory ceded by Russia in 1867—in other words that Bering Sea was mare clausum; and notice was given of this construction, with a view to preventing the pelagic fishery in those waters.

In August, 1886, an American revenue cutter seized 3 Canadian sealing vessels in Bering Sea about 60 miles from the nearest land. On October 4, these vessels were condemned for having been "found engaged in killing fur seal within the limits of Alaska Territory and in the waters thereof in violation of section 1956 of the Revised Statutes of the United States." After repeated protests on the part of the British Government, the President on January 26, 1887, without conclusion of any questions which might be found to be involved, directed "the discontinuance of all pending proceedings, the discharge of the

vessels referred to, and the release of all persons under arrest in connection therewith." Later in this same year other Canadian vessels were seized and occasioned a renewal of diplomatic controversy.

In a circular letter dated August 19, 1887, Mr. Bayard, the American Secretary of State, proposed international cooperation "for the better protection of the fur-seal fisheries in Bering Sea," sending the communication to the American ministers in France, Germany, Great Britain, Japan, Russia, and Norway and Sweden, for presentation to those respective Governments.[a] The preliminary steps seemed to be viewed favorably by the Governments of France, Great Britain, Japan, and Russia, and "the convention had been virtually agreed on verbally, except in its details;"[b] but in May, 1888, these were suspended by reason of opposition made by the government of Canada, without whose assent Great Britain would not act.

In 1888 no seizures were made of foreign vessels in Bering Sea. But in 1889 the American Government renewed its activity against the pelagic fishery and arrested a number of British Columbian vessels outside the 3-mile limit, claiming that "the Canadian vessels arrested and detained in the Bering Sea were engaged in a pursuit that was in itself contra bonos mores, a pursuit which of necessity involves a serious and permanent injury to the rights of the Government and people of the United States,"[c] the ownership of the fur seals resulting from ownership of the islands on which they breed and of the coast on which they live. Unfortunately, however, there was no exact precedent in international law for treating the fur seals as the subject of property on the high seas, and indeed no municipal law of the United States had ever so considered them.

Diplomatic correspondence continued between the two Governments, and pending negotiations for the reference of the controversy to a tribunal of arbitration, a modus vivendi was agreed to on June 15, 1891. By this agreement Great Britain undertook to prohibit, until the following May, the killing of fur seals by British subjects in that part of Bering Sea lying eastward of the line of demarcation described in the treaty of 1867 between the United States and Russia, and the United States to prohibit the like killing of seals by citizens of the United States in the same part of Bering Sea and on the islands thereof, in excess of 7,500 to be taken on the islands for the subsistence and care of the natives.

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[a] "Without raising any question," said Mr. Bayard, "as to the exceptional measures which the peculiar character of the property in question might justify this Government in taking, and without reference to any exceptional marine jurisdiction that might properly be claimed for that end, it is deemed advisable to attain the desired ends by international cooperation." (S. Ex. Doc. 106, 50th Cong., 2d sess., 84.)

[b] Letter from Mr. Phelps, American minister at London, dated September 12, 1888.

[c] Letter from Mr. Blaine, Secretary of State, to Lord Salisbury, January 22, 1890.

On April 18, 1892, a second modus vivendi was concluded embodying the provisions of the modus vivendi of 1891, with the added subject of compensation for damages to be paid "by the United States to Great Britain (for the use of her subjects) for abstaining from the exercise of that right during the pendency of the arbitration upon the bases of such a regulated and limited catch or catches as in the opinion of the arbitrators might have been taken without an undue diminution of the seal herds; and, on the other hand, if the result of the arbitration shall be to deny the right of British sealers to take the seals within said waters, then compensation shall be made by Great Britain to the United States (for itself, its citizens, and lessees) for this agreement to limit the island catch to seven thousand five hundred a season, upon the basis of the difference between this number and such larger catch as in the opinion of the arbitrators might have been taken without an undue diminution of the seal herds."

On February 29, 1892, the two Governments agreed to refer to a tribunal of seven jurists the question of jurisdiction over the fur seals in Bering Sea, and what concurrent regulations were desirable for their protection outside the jurisdictional limits of the respective Governments. The tribunal of arbitration met in Paris in 1893. The American claim of exclusive jurisdiction was not strongly pressed, and the principal issue was: "Has the United States any right, and if so, what right, of protection or property in the fur seals frequenting the islands of the United States in Bering Sea when such seals are found outside the ordinary three-mile limit."

On the question of property in the fur seals, the United States claimed that these are not entirely feræ naturæ, but are in part domesticated, as is the honey bee; that ownership in the islands upon which fur seals breed, that their habit in regularly resorting thereto and rearing their young thereon, that their going out in search of food and regularly returning thereto, and all the facts and incidents of their relation to the islands gave to the United States a property interest therein; and that this was such a property interest as entitled the Government to preserve the herd from destruction by employment of such reasonable force as may be necessary, even at considerable distance from the islands.

Irrespective of this distinctive right of property in the fur seals, the American Government claimed for itself and its people an interest and an industry in the proper use of the fur-seal herd on its territory, which it was entitled to protect against wanton destruction by individuals for the sake of the small and casual profits in that way to be gained; and that no part of the high seas is or ought to be used by individuals for the purpose of accomplishing the destruction of national interests of such a character and importance. Furthermore, the United States, alone possessing the power of preserving this valuable interest, was in a most just sense the trustee thereof for the benefit of mankind and should be permitted to discharge that trust without hindrance.

On the question of ownership in the migrating seals, the decision of the arbitrators in the tribunal, by a majority of five against two, was that "the United States has not any right of protection or property in the fur seals frequenting the islands of the United States in Bering Sea, when such seals are found outside the ordinary 3-mile limit." As provided for in this event, a system of regulations was formulated for the protection of the herd outside the jurisdictional limits, to be enforced jointly by the two nations, the cruisers of each of the two powers being authorized to visit, search, and arrest all violators,[a] but a seized vessel must be conveyed to a harbor of her home state and turned over to the authorities there for trial.

These regulations provided for a suspension of all pelagic sealing in Bering Sea in May, June, and July, which covers the breeding season; and they interdicted sealing at any time within a zone of 60 geographical miles around the Pribilof Islands, which was supposed to cover practically the feeding ground of the mother while her young is dependent on her for nourishment. Licensed sailing vessels only were permitted to engage in the fishery, and the use of nets, firearms, and explosives was interdicted. These regulations were to remain in force until abolished by mutual agreement, but were to be examined every five years with a view to modification.[b]

For executing these regulations, an act was approved in the United States on April 6, 1894,[c] and a similar act was passed by Parliament[d] on the 23d day of the same month. Other maritime powers were asked by the United States to submit voluntarily to the regulations made by the arbitrators, but only Italy has agreed to this[e] and all other nations remain free to engage in pelagic sealing at any time without regard to the closed season mentioned in the award.[f] But as the fishery was then practiced almost wholly by vessels flying either the Canadian or the American flag, it was virtually subject to the regulations of the Paris tribunal.

In 1894 these regulations were enforced by the two interested Governments among their respective subjects, the United States spending over $500,000 in maintaining its patrol. But notwithstanding this protection, the pelagic catch of fur seals exceeded that of any preceding year, amounting to 61,838, as com-

[a] This is one of the three instances in which the United States has consented to a departure from its stoutly maintained policy of freedom of its merchantmen from search by foreign cruisers in time of peace, the successful advocacy of which forms one of the most glorious records in American history.

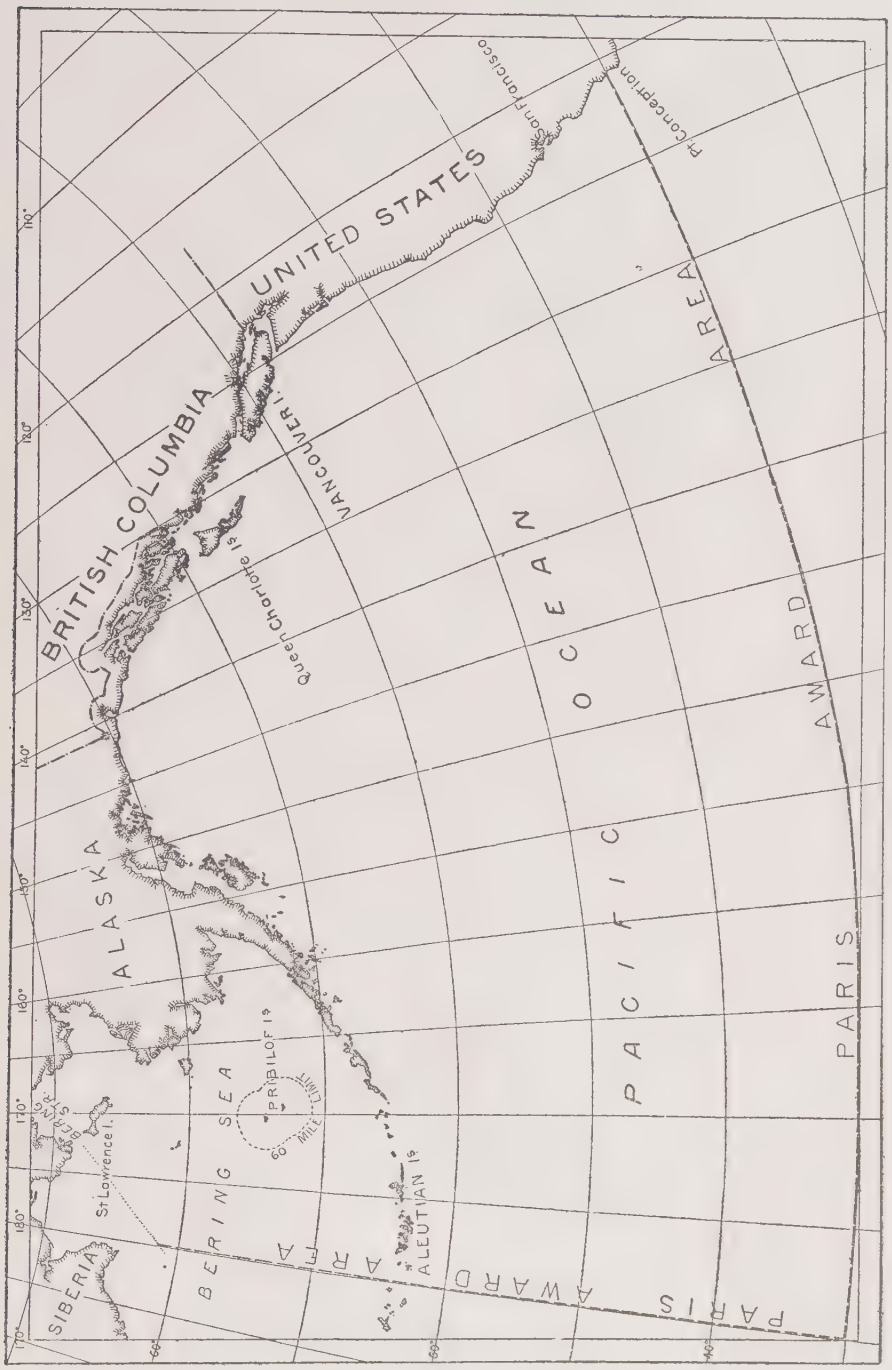
[b] These regulations are given in detail in Appendix G (page 173 of this paper).

[c] 28 Stat. L., 52.

[d] Foreign Relations, 1894, App. 1, p. 107–233.

[e] Martens, Nouveau Recueil General de Traites, 2d series, XXII, p. 565.

[f] France and Portugal signified their willingness but do not appear to have executed the regulations. The Government of Denmark declined to adopt them on the ground that no vessels of that nation were engaged in sealing in those waters. Japan declined to enforce them among its vessels unless similar protection should be given to the Japanese fur-seal fisheries. And Russia consented to adhere to the regulations only on condition that they be extended to the whole of the Pacific Ocean north of the thirty-fifth degree of latitude. (Moore, Digest of International Law, p. 922–923.)



Map showing area designated in the award of the Fur-seal Arbitration Tribunal.

pared with 30,812 in 1893, owing principally to the fact that the mother fur seals feed far outside of the protected zone. The vessels followed the herd as it moved along the coast in the spring and entered Bering Sea at the end of the close season in August, when under the ineffectual regulations they were free to use the spear outside the 60-mile zone. The pelagic catch in Bering Sea during 1894 numbered 31,585, of which over 80 per cent were taken by Canadian vessels.

The higher value and the greater abundance of fur seals in the Pribilof herd had resulted in attracting to it the attention of the pelagic sealers, so that previous to 1891 the herd resorting to the Russian islands was relatively free from their attention. But the prohibition of fur sealing within the limits agreed upon in the modus vivendi of 1891 and in that of 1892 resulted in diverting the fleet to the Russian coast, and caused such a destruction in that herd that measures of protection were imperative. In 1892 the Russian authorities arrested 6 vessels charged with fur sealing within the marine league about Copper Island.

On February 12 (24), 1893, in response to an inquiry from the British ambassador, made in behalf of Canadian sealers, as to the limits within which they would be permitted to take seals, the Russian minister of foreign affairs wrote that the insufficiency of the strict application of general rules of international law to this matter was conceded in the negotiations between Great Britain, the United States, and Russia in 1888, and that the necessity for exceptional measures had been confirmed by the Anglo-American modus vivendi of 1891, which had placed Russian interests in an abnormal and exceptional position. As a matter of self-defense, for the ensuing season and pending the adoption of international regulations, Russia would prohibit sealing within a zone of 10 miles on all her Pacific coasts, and within a zone of 30 miles around the Commander Islands and Robben Island. Although denying that Russia had a right to extend her jurisdiction beyond the usual territorial limits, in view of the existing conditions the British Government expressed willingness to enter into an agreement with Russia for the enforcement of these protective zones. Such an agreement was concluded in May, 1893,[a] and an order in council was issued on November 21, 1895, to give effect to this arrangement.

On May 4, 1894, a somewhat similar modus vivendi was concluded between the Governments of Russia and the United States. This provided, on the one hand, that the United States would prohibit its citizens from taking fur seals within a zone of 10 nautical miles along the Russian coasts of Bering Sea and of the North Pacific Ocean, as well as within a zone of 30 nautical miles around the Commander Islands and Robben Island; and, on the other hand, that the Russian Government would limit to 30,000 the number of fur seals to be taken during the year 1894 on the same islands. It was agreed that this provisional

[a] See Blue Book, "Russia, No. 1, 1893."

expedient might be terminated at will by either party upon giving notice to the other.

The fur seals in the Pacific continued to decline so rapidly in numbers that in 1896 Great Britain and the United States agreed to the appointment of a joint scientific commission to study the fur-seal life in Bering Sea with a view to greater protection. The investigations of this—the Jordan-Thompson—commission covered the seasons 1896 and 1897, and led to the conclusion that the cause of the decline was the killing of females at sea, and that the abolition of pelagic sealing was essential to the preservation of the herd. It was expected that the joint high commission called at Quebec in 1898 would act upon this finding, but unable to reach an agreement on the boundary dispute between Canada and the United States, that commission suspended without taking action, and the fishery has continued up to the present date under the very ineffective arbitration regulations of 1893.

So far as concerns the actual preservation of the fur seals from commercial ruin and extermination, it probably is not too much to say that virtually nothing has been accomplished by all the negotiations and arbitrations during the last thirty years. And while restriction of the pelagic fishery may have served to retard somewhat the exhaustion of this resource, it has been entirely out of proportion to the expense involved.

The official returns show that from 1890 to 1901 the American Government expended $3,357,097 for this purpose, as follows:

United States navy patrol	$1,603,048
Revenue-cutter patrol	1,299,735
Expenses of Paris tribunal	234,000
Award of damages, pelagic sealers' arrest	473,151
Cost of Jordan-Thompson Commission	30,000
Cost of treasury agents	317,163
Total	3,357,097

In view of the inefficiency of the regulations established by the Paris tribunal of 1893 and the great destruction of the herd, the American Government has made additional efforts to put a stop to the pelagic fishery. It has prohibited the fishery to its citizens; and, after ineffectual efforts to induce other governments to do likewise, has attempted to reduce the value of the pelts to the point where subjects of other governments would find no profit therein, employing such measures as branding all female seals on the islands, and interdicting the importation into this country of any fur-seal skins taken in the pelagic fishery. Probably the most extreme measure was introduced in the Fifty-fourth Congress. This bill, which passed the House unanimously, but failed in the Senate, required that in the event that the President failed to negotiate a satisfactory agreement with the Government of Great Britain for the preservation of the herd, the Secretary of the Treasury should cause to be

slaughtered every fur seal on the Pribilof Islands, without provision for the preservation of the species.

It is generally agreed that the preservation of the fur seals involves the complete elimination of the pelagic fishery. At present this is prosecuted only by vessels from Canada and Japan, the fleet of the latter having increased rapidly since 1893. The 15 vessels composing the Canadian fleet in 1907 secured 2,858 skins from Bering Sea, 448 from the vicinity of Copper Islands, and 1,934 from the British Columbia-Alaska coast, a total of 5,240 skins. In accordance with the provisions of the Paris award, these vessels are prohibited from killing seals in Bering Sea at any time with firearms or in any manner within a distance of 60 miles about the Pribilof Islands, and must observe a closed season between May 1 and July 31 of each year. The 36 vessels in the Japanese pelagic sealing fleet in 1907 secured about 9,000 skins in Bering Sea and the North Pacific Ocean, hunting in any manner and anywhere outside the marine league, as these vessels are not bound by the regulations of the Paris tribunal. During the greater part of the summer the Japanese vessels hovered about the Pribilof Islands, killing seals just outside the 3-mile territorial limit.

For years an effort has been made to induce the Canadian government to prohibit her fishermen from engaging in the pelagic fishery. But since this is a vested interest in which the right of her citizens was established by the decision of the Paris tribunal, and since such an interdiction would be almost exclusively for the financial advantage of America and Russia, the Canadian government has not seen fit to follow such a course. It has been suggested that for a definite sum of money the right of the Canadians to take seals on the high seas be sold to the American Government; but many practical and legal difficulties attach to this course, aside from any question as to whether it would meet with the approval of the nations interested. Since a termination of the pelagic fishery would promote the prosperity of the sealing on the rookeries, a more equitable plan would seem to be an exchange with the Canadian government of a share in the revenue from the rookeries for a prohibition of the pelagic fishery.

Some years ago the Japanese Government professed a willingness to concur in any agreement made between Great Britain and the United States for preserving the fur seals. However, that was before so many Japanese vessels were employed in the pelagic fishery, and possibly that Government might not now be so willing to abandon this vested interest without some equivalent. Any arrangement made with the Canadian government which is not concurred in by the Japanese Government would be wholly valueless, for experience of the last few years has shown how easy it is for a Canadian sealer to place his boats under the Japanese flag. Indeed, even should arrangements be made with both Canada and Japan, there would be no assurance that vessels of other nationalities might not engage in the pelagic fishery.

CONVENTION OF 1899 BETWEEN SWEDEN AND DENMARK.

In the narrow waters connecting the Baltic and the North Sea much confusion developed near the close of the last century between the fishermen of Sweden and Denmark, particularly as to the limits of territorial jurisdiction from which they were respectively excluded. This resulted in a convention, signed on July 14, 1899, which set forth the limits of territorial jurisdiction and extended to the subjects of each nation certain privileges within the territorial waters of the other; it also required that boats, fishing gear, etc., should be suitably marked and that avoidable injury thereto should be assessed against the person responsible.

This convention [a] was not so broad in its scope as the North Sea convention of 1882 or the Anglo-Denmark convention of 1901. For its purposes the waters between Sweden and Denmark were defined to be: (1) The Cattegat, limited by a line on the north extending from Skagen to Vinga light-house and thence to Hesingen Island, and on the south by lines extending from Hasenore to Gniben and from Kullen to Gilberghaven; (2) The Sound or Örasund, extending from the Kattegat on the north to a line drawn from Falsterbo to Stevns on the south, and (3) the navigable waters of the Baltic along the coast from Falsterbo to Simbrishamn and also around the Danish islands Bornholm and Kristiansö.

The area reserved to the subjects of each country extends seaward to the distance of 4 geographical miles (one-fifteenth of a degree of latitude) from the coast—that is, the outermost islands and the reefs not constantly covered by water. But in the Cattegat Swedish subjects are authorized to fish within a distance of 3 geographical miles of the shores of the Danish island Anhalt, and Danish subjects are authorized to fish at the same distance outside a straight line drawn from Hallands Wäderö light-house to Tylo light-house on the Swedish coast.

The convention made two other exceptions to the 4-mile rule, viz: (1) In The Sound the subjects of each country are authorized to fish everywhere without discrimination, with this limitation, that along the shores of each side within a depth of 7 meters the subjects of the other country are not permitted to catch any other fish than herring; and (2) in the Baltic along the shores of Bornholm and Kristiansö islands and on the Swedish coast from Falsterbo to Cimbrishamn fishing for herring with nets is permitted to the subjects of each country from May 1 to August 31.

The convention defined the manner in which the vessels and the various forms of fishing gear shall be marked. In accordance with its provisions, whenever a subject of either country occupies a fishing station with his gear duly marked he may not be ousted therefrom. If fishing gear is set or hauled over marked gear, or if a net is so hauled that duly marked gear is needlessly

[a] The original text and a translation of this convention are given in Appendix H (page 174 of this paper).

damaged, the owner thereof has the right to indemnity from the person causing the damage. This protection applies to salmon gear set around Bornholm and Kristiansö islands only from October 1 to April 1, inclusive.

Offenses against the convention are to be reported and tried in the country to which vessel of the guilty party belongs, and the punishment consists of fines ranging from 10 to 200 crowns.

A protocol to this convention set forth that the respective Governments would take the necessary measures for executing the provisions of the convention and especially those relating to police supervision; and furthermore that differences of opinion regarding the interpretation or application of the convention which could not be adjusted by diplomatic negotiations should be submitted to arbitration. The convention and protocol were ratified at Copenhagen on July 21 and at Marstrand on August 4, 1899, and the ratifications were exchanged at Stockholm on November 10, 1899.

On October 5, 1907, this convention was supplemented by a declaration, taking effect November 1, 1907, which specified that in The Sound fishing shall be permitted to the subjects of each country everywhere without restriction other than that along the shores of each side of the sound within a depth of 7 meters subjects of the other country shall not fish with nets for any other species than herring. And in the Baltic Sea along the coast of Bornholm and Kristiansö islands and on the Swedish coast from Falsterbo to Cimbrishamn the herring fishery with draft nets shall be common to the subjects of each country from May 1 to August 31.

The declaration also added this important provision: Plaice less than 25½ centimeters in length (21 centimeters from the point of the nose to the root of the tail) shall not be permitted on board any fishing vessel in the Cattegat, its bays or inlets, nor shall any such plaice be landed, sold, or shipped from one locality to another on the coasts of the Cattegat, but shall be returned to the water as quickly and as uninjured as possible. The same provisions apply to The Sound, excepting that in certain towns plaice 21 centimeters long (17 centimeters from the point of the nose to the root of the tail) may be used for consumption in the communes lying next to the coast.

GREENLAND SEAL FISHERY REGULATIONS OF 1875–1877.

Although they are not strictly international in the sense of binding the interested states in their relations with each other, yet it seems that reference should be made to the concurrent regulations enacted in 1875–1877 by Great Britain, Denmark, the Netherlands, Norway, and Sweden for protecting hair seals in the seas adjacent to the eastern coast of Greenland, and especially about the island of Jan Mayen.

Very rapid is the growth of the young seals born each March on the ice floes drifting down from the polar sea. The skin, with the attached fat, weighs only about 8 pounds at birth; but nourished by their mothers' milk on the icy

cradles the young animals increase rapidly in weight, so that at four weeks the pelt weighs about 40 or 50 pounds and the oil and the skin are in prime condition for commercial use. At this age the young seals are easily captured by vessels which penetrate among the ice floes, carrying men who descend upon the ice and club them to death in large numbers, single vessels sometimes slaughtering several thousand in a day.

There are two principal fisheries for seals in the northern Atlantic, the so-called Newfoundland fishery and the Jan Mayen or Greenland fishery. Although two or three of the vessels are owned in Scotland, the Newfoundland fishery is prosecuted entirely from St. Johns in that colony, so that colonial legislation has been found sufficient for its regulation and protection. The Greenland fishery is carried on between Greenland, Spitzbergen, and the island of Jan Mayen, but mostly within 400 miles of that island; and the vessels engaged therein have sailed from Scotland, Norway, Germany, and to a less extent from Denmark and Sweden.

Forty years ago this fishery was extensive, the annual take of pelts numbering about 200,000. Owing to the small area on which the seals breed and the large number of vessels employed, there was much competition among the fishermen in being the first on the ground, and very many young seals were slaughtered within a few days after birth, when they were wholly defenseless, making no effort to escape from the clubs of the hunters, and almost complete extermination of the herd was relatively easy. Furthermore, the pelts secured were very small, whereas had they been permitted to remain for two weeks longer the average value would have been several times as great.

There has never been an international convention, treaty, or arbitration for protecting these animals, but a close season has been established through analogous municipal enactments by each of the interested nations acting in concert. Norway and Sweden took the initiative in this matter and by informal concert were quickly followed by Great Britain, Denmark, and the Netherlands. Each power legislated independently for itself, and its legislation operated only on its own subjects. These regulations may be repealed, respectively, at the pleasure of the enacting state without notice to the other powers interested. Each nation acts with complete independence in the enforcement of its own regulations, no provision whatever being made for one government to arrest or otherwise interfere with foreign fishermen violating the regulations, which is probably the principal feature of the important conventions previously discussed in this paper.

In Great Britain legislation on this subject began with an act of Parliament passed on June 14, 1875 (38 Vict., ch. 18), which empowered the Queen in council, being satisfied that other powers concerned had made or would make the like regulations as to their ships and subjects, to prescribe a close time for the seal fishery in the area included between the parallels of 67° and 75° north latitude, and the meridians of 5° east and 17° west longitude from Greenwich,

covering an area of about 285,000 square miles. On November 28, 1876, an order in council was made bringing the act into operation and fixing the 3d of April in each year as the earliest day on which it should be lawful to take seals in that region. Concurrent action was taken by Denmark, the Netherlands, Norway, and Sweden; but, despite these regulations, the fishery has gradually declined, and since 1900 relatively few seals have been taken in these waters. So far as we are aware, this is the only instance in which Norway has acted in concert with other nations in regulating any branch of the fisheries on the high seas other than those designed for protecting submarine cables.

EXTENSION OF TERRITORIAL JURISDICTION.

As has been set forth in the first chapter of this paper, a nation can not independently establish any regulations over fisheries prosecuted by foreigners on the high seas. Each nation legislates for itself, and its regulations can operate on its subjects alone.

But has a state no power whatever to safeguard its marginal fishery resources by regulations applicable on the adjacent high seas to foreigners as well as to subjects? If the marginal resources are jeopardized by some very destructive procedure of foreign fishermen immediately outside territorial waters, would not international law sanction interference with those operations in order to preserve sustenance and livelihood to the coastal population? Even as nations now exercise jurisdiction over foreign vessels beyond the marine league for enforcing quarantine and revenue laws, may not authority somewhat analogous be exercised to preserve the fishery resources within the marine belt?

This principle of interference and protection, applied to a concrete case was the chief contention of the United States before the Bering Sea tribunal in 1893; and the assumption of such authority is greatly discredited by the decision in that case, which must be regarded as an authoritative declaration of international law. It is universally admitted that pelagic sealing is highly destructive and threatens the existence of the fur seals in the territorial waters and on the shores of the United States, to the great loss and injury of American subjects; and yet it was decided that the nation is powerless to prevent their destruction by foreign fishermen. Indeed, unless there be special agreement to the contrary, foreign fishermen may remain just outside the marine league and slaughter every seal that ventures that far from the shore, even to the last member of the herd, and the American Government is without authority to interfere. A similar condition exists about the Russian islands, and the Japanese fishermen endeavor to make the most of their rights in this respect, off the American as well as the Russian shores.

The recent action of the British Government in excluding foreign fishermen from trawling in the Firth of Moray, on the eastern coast of Scotland, seems at variance with the conclusions of the Bering Sea tribunal. In 1889 (52 and 53 Vict., ch. 23, July 26, 1889), Parliament authorized the Fishery Board for Scotland,

for the purpose of protecting the spawning grounds, to interdict trawling within a line drawn from Duncansby Head, in Caithness, to Rattray Point, in Aberdeenshire, a distance of 85 miles, inclosing an area of about 1,700 square miles outside the British maritime belt, all of which had been defined as a part of the high seas in the North Sea convention of 1882. Although neither the statute nor the by-law made, confirmed, and published thereunder was explicit on this point, it was generally understood—indeed, semiofficial expressions seemed to justify the construction—that this enactment applied solely to British subjects, and had no reference to the operations of foreign fishermen.

In November, 1905, Emmanuel Mortensen, captain of a Norwegian vessel, the *Niobe*, was arrested and charged with trawling in Moray Firth about 5 miles from land, contrary to this by-law. When found guilty in the lower court, the defendant appealed the case[a] on the ground of nonjurisdiction of the court, the alleged offense having been committed on the high seas 5 miles from land. After able argument on each side, the court dismissed the appeal on the ground that as Parliament had, apparently from the enactment, assumed jurisdiction over the water in question for the purpose of regulating the fisheries, the court was bound to give effect to its terms, and that it was not for the court to question whether the legislature had done what foreign powers might consider an usurpation.[b] Owing to her peculiar policy in regard to wide claims over marginal waters, no exception was taken to the action of the British Government by the Kingdom of Norway, to which country the arrested vessel belonged; and as no other nation was concerned in that particular case, the claim to jurisdiction has not been brought into international review, where possibly it would share the fate of several previous attempts to extend jurisdiction beyond the marine league.[c]

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[a] Mortensen *v.* Peters (High Court of Judiciary, full bench). Reported in The Scots Law Times, vol. XIV, p. 227, August 4, 1906.

[b] This decision is in accord with the rule in this country, where in a controversy between the United States and a foreign nation as to boundary, the courts follow the decision of those departments of the Government to which the assertion of its interests against foreign powers is confided, i. e., the legislative and executive. (Moore, Digest of International Law, sec. 154.)

[c] Indeed, the opinion has been expressed by eminent authorities that seizures beyond the marine league for revenue purposes can not be sustained as a right, and that revenue laws authorizing such action are enforceable at peril, and rest on the tacit permission of the states whose vessels may be seized. In his opinion given to the Sardinian Government in the case of the *Cagliari*, Sir Travers Twiss added: "In ordinary cases, indeed, where a merchant ship has been seized on the high seas, the sovereign whose flag has been violated waives his privilege, considering the offending ship to have acted with mala fides toward the other state with which he is in amity, and to have consequently forfeited any just claim to his protection." And Dana writes: "Doubtless states have made laws for revenue purposes touching acts done beyond territorial waters, but it will not be found that in later times the right to make seizures beyond such waters has been insisted upon against the remonstrance of foreign states, or that a clear and unequivocal judicial precedent now stands sustaining such seizures when the question of jurisdiction has been presented." And he adds, in the same connection: "It may be said that the principle is settled that municipal seizures can not be made for any purpose beyond territorial waters. It is also settled that the limit of these waters is, in the absence of treaty, the marine league or the cannon shot." (Dana, note 108, Wheaton's International Law, sec. 179, p. 258–260.)

The action of the British Government appears inconsistent with its attitude in the Bering Sea controversy, and seems to be a revival of the view taken a century ago by our own Chancellor Kent, who suggested that, considering the length and characteristics of the American coasts, the United States might claim control of the waters included within lines stretching from distant headlands, as, for instance, from Cape Ann to Cape Cod, from Nantucket to Montauk Point, from Montauk Point to the capes of Delaware, and from the South Cape of Florida to the Mississippi;[a] but which was said by Woolsey to be "out of character for a nation that has ever asserted the freedom of doubtful waters, as well as contrary to the spirit of more recent times,"[b] and has never been accepted as an expression of the policy of the American Government.

As a purely academic proposition, instances could be suggested in which it might seem that a nation would be warranted in interfering with some novel and highly destructive method of fishery employed contiguous to her marginal seas. For instance, it is not to be supposed that any of the countries bordering the North Sea would willingly tolerate the use of large quantities of poison or of dynamite in taking fish in those waters, or that similar destructive methods would be permitted on the Newfoundland banks, even though these vicious acts should be committed by foreigners operating more than 3 miles from land and with the approval of their Government. But in the light of the Bering Sea decision, very slight is the probability of an instance actually arising in which a nation would unquestionably be justified in interfering with a method of fishery prosecuted by foreigners on the high seas, for no single nation may arrogate to itself executive power for the enforcement of international law. The provocation would have to be so great as to threaten the very existence of its people, and it is scarcely presumable that a foreign government would permit its subjects thus to injure the resources of a friendly state, for the public opinion of the civilized world enforces submission from every nation. Obviously the exercise of this authority for a merely beneficial restriction or regulation would likely soon become the basis of complete jurisdiction over that particular area, and it would probably not be long before, through one pretext or another, the principal fishing grounds of the world would pass under control of individual powers. And, to quote the words of Dr. C. N. Gregory: "No right to regulate what belongs to all nations can be conceded to one nation, however large her interests or enlightened her councils."[c]

For the preservation of the coastal fisheries, as well as for the more important matters of national defense and safety, the opinion is growing that the present limit of the marginal belt is too narrow and that it should be extended considerably beyond the present distance of 3 miles. As already set forth

[a] Kent, Commentaries on American Law, vol. 1, sec. 29, 30.
[b] Woolsey, International Law, sec. 60.
[c] American Political Science Review, May, 1907, p. 436.

herein, the marine league had its origin in the range of cannon, which determines the distance over which a nation is able to exercise jurisdiction from the shore. As the efficiency of cannon has greatly increased, and is now considerably more than 3 miles, it is urged that the width of the maritime belt should increase correspondingly. In recent years most of the writers on international law have expressed views favorable to this extension.

As written by Oppenheim, one of the most recent and likewise interesting of all writers on international jurisprudence: "Although many states, in municipal laws and international treaties, still adhere to a breadth of one marine league, the time will come when by a common agreement of the states such breadth will be very much extended." [a]

The learned editor of the 1904 edition of Hall's International Law expresses the view that "it is desirable for a state to have control over a larger space of water for the purpose of regulating and preserving the fisheries, the productiveness of sea fisheries being seriously threatened by the destructive methods of fishing which are commonly employed." [b]

The extension of the marginal belt was discussed by the Institut de Droit International at its meeting in Paris in 1904. The general opinion was that such an extension was desirable, and it was agreed nemine contradicente to recommend an increase to 6 miles, after the proposal to extend it to 10 miles had been rejected by 25 votes against 10. [c]

In view, however, of the approval which the 3-mile margin has received in international conventions, legislative bodies, and judicial tribunals, the indefiniteness of centuries ago has become the vested rights of to-day, the once plastic cement which the workmen molded has now become so set and solidified with the passage of time that it is useless to discuss an extension of the distance of exclusive jurisdiction without absolute international agreement. It can not be denied that such an extension would be vigorously opposed by some influential interests. The trawl fishermen of Great Britain, for instance, would unquestionably object to it, and for very practical reasons. Exclusive of the White Sea and the Baltic, the trawling area outside the 3-mile limit of northern and western Europe approximates 450,000 square miles. An extension of the marginal belt 6 miles would place 81,000 square miles of this area within the territorial jurisdiction of continental countries, and an extension of 4 miles farther would exclude British fishermen from 135,000 square miles of the best trawling grounds, an area nearly equal to that of the North Sea. As the British trawling fleet greatly exceeds that of all the continental countries, the fishermen of Great Britain would have much to lose and nothing to gain by the extension. On this side of the Atlantic acceptance of the exten-

[a] Oppenheim, International Law, London, 1905, vol. I, sec. 186.

[b] Page 152.

[c] Institut de Droit International, Annuaire (1894–1895), t. XIII, p. 290, 328–331.

sion would depend very largely on how it would affect the rights and treaty privileges of the United States along the shores of the British Provinces, which possibly far more than any other factor has influenced the present firm position of this Government respecting a marginal belt of a marine league only.[a]

Probably more important from an economic point of view than several miles increase in the width of the marine belt is a clear and unquestioned international recognition of vested rights in attempts to exploit and develop definite areas of sea bottom under the high seas, as in the cultivation of sponges, corals, pearl oysters, etc. There is a distinction in law as well as in fact between such an industry and a fishery dependent on the pursuit of free-swimming fishes in the ocean. Oysters, sponges, and the like represent a peculiar kind of property. They are not feræ naturæ, as they do not stray, nor do they require taming, hence ownership may be acquired in them.

It can not be affirmed that this extension of territorial jurisdiction to sea bottoms which are devoted to the cultivation of sponges, mollusks, etc., has ever been made the basis of any treaty or agreement, or has even been the subject of diplomatic discussion. With the single exception of Vattel, the older writers on international law were silent on this matter, and even Vattel seems not to have clearly distinguished it from the exercise of jurisdiction over migratory fishes in the seas near the marginal belt,[b] a doctrine which has long since been discredited.

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[a] The attitude of the United States in this matter was well expressed by Mr. Olney, when Secretary of State: "This Government would not be indisposed, should a sufficient number of maritime powers concur in the proposition, to take part in an endeavor to reach an accord having the force and effect of international law as well as of conventional regulation, by which the territorial jurisdiction of a state, bounded by the high seas, should henceforth extend 6 nautical miles from low-water mark, and at the same time providing that this 6-mile limit shall also be that of the neutral maritime zone. I am unable, however, to express the views of this Government upon the subject more precisely at the present time, in view of the important consideration to be given to the question of the effect of such a modification of existing international and conventional law upon the jurisdictional boundaries of adjacent states and the application of existing treaties in respect to the doctrine of headlands and bays. I need scarcely observe to you that an extension of the headland doctrine, by making territorial all bays situated within promontories 12 miles apart instead of 6, would affect bodies of water now deemed to be high seas and whose use is the subject of existing conventional stipulations." (Letter to Mr. de Weckherlin, Dutch minister, February 15, 1896. And we may also refer in this connection to the letter of Mr. Secretary Seward to the Spanish minister, quoted on p. 107.)

[b] Said Vattel: "Who can doubt that the pearl fishery of Bahren and Ceylon may not lawfully be enjoyed as property? And though a fishery for food appears more inexhaustible, if a nation has a fishery on its coasts that is particularly advantageous, and of which it may become master, shall it not be permitted to appropriate this natural advantage to itself, as a dependence on the country it possesses; and, if there are a sufficient number of fish to furnish the neighboring nations, of reserving to itself the great advantage it may receive from them by commerce? But if, so far from taking possession of it, it has once acknowledged the common right of other nations to come and fish there, it can no longer exclude them from it; it has left that fishery in its primitive freedom, at least with respect to those who have been in possession of it. The English not having taken the advantage from the beginning of the herring fishery on their coast, it is become common to them with other nations." (Vattel, Le Droit des Gens, lib. 1, ch. 23, sec. 28.)

Very natural, however, was the silence of the older publicists on this subject, since there was no occasion for recognition of this view until a very recent period. The spirit of scientific investigation and of industrial development is everywhere, and in few directions have these made greater progress in the last score or two of years than in the possibilities of cultivating the sea bottoms. Millions of dollars worth of oysters are now grown on areas which thirty years ago were barren wastes. Biologists are obtaining excellent results in sponge culture in the Gulf of Mexico, and in coral growth in the Mediterranean. Careful observers are awakening to the possibilities of pearl culture, not simply to raise the mollusks which yield pearls fitfully and at rare intervals, but to insure and to increase the yield of pearls within these mollusks, and thus to obtain remunerative returns without the arduous toil and the element of hazard inseparable from pearling as now prosecuted. And must the work of these investigators, must the enterprises which they stimulate, be restricted to the bounds of the marine league, while the broad areas of shallow bays and gulfs remain barren? Must we plant and harvest but along the hedgerows of the maritime belt and leave the rich meadows of the sea bottoms to waste? Must the work be handicapped by the refusal of international law to concede to these enterprises the elements of private ownership, which must be wholly lacking unless territorial jurisdiction apply to the areas which they exploit?

Numerous instances exist in which fisheries for pearl oysters, etc., prosecuted beyond the marginal belt, are the subject of fostering care on the part of a government or its people. By careful supervision as to close seasons, size limits, etc., and in some cases special preparation of the bottom and even removal of predacious enemies, the output from these areas is conserved and increased. Instances of this kind under state authority or recognition may be regarded as an occupation of the bed of the sea, and territorial jurisdiction should rightly extend to them, even though they be carried on beyond the marginal belt ordinarily recognized by international law. Even Grotius' "Mare Liberum" is founded upon the old doctrine of Roman law that there can be no property in anything without occupation. And while the vagrant waters of the ocean can not be subjected and occupied, the sponge beds and pearl reefs can be, even as the hills and the mountains.

It is not difficult to find opinions and analogies among the authorities tending to the view that international law would extend protection to enterprises under state authority for cultivating the sea bottom without any question as to whether the strict territorial limits have been exceeded. Even as a nation, by building a light-house upon the bed of a rock or upon piles driven into the bed of the sea, acquires territorial jurisdiction over the space thus occupied, so it would seem that a portion of the bed of the sea might be exploited and occupied in like manner, and that ordinary territorial law would apply to it.

In the celebrated Franconia case,[a] Chief Justice Cockburn, of England, noted that a portion of the bed of the sea, where it could be physically, permanently occupied, might be subject to occupation in the same way as unoccupied territory. And as said by Vattel, the most popular and in many respects the most just of the writers on the law of nations: "Qui doutera que les pêcheries de Bahrein et de Ceylon ne puissent legitimement tomber en propriété?"[b]

This view is founded not only on justice but likewise on necessity. Man's eagerness has so nearly exhausted the easily exploited resources that fostering care is essential to the best development and use of the sea bottom. Left to the chance of nature and subject to despoilment by every one without hindrance, these areas would remain barren wastes. Law and government are for the benefit of humanity. The aim of international law is the welfare and happiness of the general society of mankind, and this would not be promoted by a policy which would keep the sea bottoms forever unproductive. The reason for the freedom of the high seas is the freedom of intercourse and commerce between the states, the seas being the common highway; and a recognition of the occupancy by an individual nation of so much of the sea bottom as it may actually improve and develop does not impair the perfect freedom of navigation by vessels of all nations, as this occupancy is subordinate to the right of navigation and can not be exercised in derogation thereof.

Necessarily in the recognition of this jurisdiction the interests of the various states should be carefully guarded, and especially of those near the areas to be exploited. Within general limits the right of exploitation and development must be reserved to the nation within whose sphere of influence the particular area is situated, for it would be manifestly unjust, indeed extremely unwise, to establish a principle by which a nation could appropriate to itself a resource off the shores of a less enterprising country. The privilege of exploiting the sea bottom in the whole of the Gulf of California, for instance, should undoubtedly rest with the Mexican people; Ceylon and British India should have control of that in the Gulf of Manar, and the riparian states should possess those in the Persian Gulf and the Red Sea.

PRESERVATION OF THE FISHERIES ON THE HIGH SEAS.

The fisheries prosecuted on the high seas are of vast economic importance; they furnish a livelihood to a large number of persons, and yield food products of great value in the sustenance of the human race. Unlike the mineral and the agricultural resources, this wealth can not be appropriated and conserved by individual enterprise, but must in a very large measure be maintained for the use of the people in common. Thus the governments of the world are in a just sense the trustees for the management of this great wealth, this common field where all reap and none sow, where all harvest and none plant.

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[a] Queen *v.* Keyn, L. R. 2 Exchcq. Div., 63 (Nov. 11 and 13, 1876).

[b] Vattel, Le Droit des Gens, t. 1, ch. 23, sec. 28.

While at present the high seas yield about 1 per cent of the food of man, an examination of the conditions leads to the belief that there are potentialities of an enormous increase. All animal nutrition may be traced to a vegetable origin. Although marine vegetation does not grow in forest-like masses, yet owing to its distribution at different depths and to the extensive area of the seas, its production probably exceeds that on land. Practically all of it is available for animal nutrition, whereas a very considerable part of land vegetation is not available for food. Thus marine vegetation either directly or indirectly supports a great quantity of animal life, which in aggregate weight doubtless equals the continental animals. In consideration of these conditions, it seems that when the increase in population of the earth requires much more thorough utilization of our resources, the draft on the seas will be vastly increased and they will be far more important factors in the food problems of mankind.

It is to the common interest of all nations to prevent indiscriminate destruction and consequent extermination of resources which contribute so extensively to the commercial wealth and general use of mankind. Useless destruction is a crime against posterity. Doubtless a century hence no policy of our great President will add more largely to his credit than his efforts toward preserving the natural resources, and no branch of these resources calls for more thorough international consideration and action than the resources of the high seas.

Upon the subject of the preservation of these resources, so that their yield may continue undiminished, there is so much that is appropriate to be said that one is lost in the abundance of it. The animal and vegetable products of the seas differ almost as widely in their characteristics and needs as those on land, and equally diversified and complicated are the problems concerning the most favorable conditions of their production and development. But within the limits of this paper it is possible to discuss these questions only in the most general way.

Fortunately the problem of sewage pollution, doubtless the greatest destructive factor in the inland and the coastal fisheries, has little or no existence in a consideration of the resources of the high seas.

From the standpoint of protective needs, the fishery products of the high seas may be roughly divided into four general classes, viz: (1) The migratory species, such as herring, mackerel, bluefish, etc.; (2) the bottom or demersal species, such as cod, haddock, flounder, and flatfish, which are less migratory in their habits and remain in the same general locality; (3) the aquatic mammals; and (4) those products which are fixed to the bottom and are susceptible of ownership, as sponges, pearl oysters, etc.

As regards the migratory fishes, there is an increasing belief that serious impairment of these species is beyond our present demands on them, and that

the present destruction effected by man is but child's play compared with nature's work in that direction. Many states from time to time have enacted restrictive legislation with a view to preserving them, but estimation of the beneficial effect of these regulations is generally discredited, at least so far as concerns the present extent of the draft on these resources.

For the purpose of protecting the spawning mackerel in their spring migration the United States, in 1887, indirectly restricted their capture for a period of five years, beginning March 1, 1888. The enactment interdicted not the fishing itself, but the importation of the fish, and applied to those caught on the high seas by foreign fishermen as well as to the catch by American citizens. It provided that "for the period of five years from and after the first day of March, 1888, no mackerel, other than what is known as Spanish mackerel, caught between the first day of March and the first day of June, inclusive of each year, shall be imported into the United States or landed upon its shores: *Provided, however*, That nothing in this act shall be held to apply to mackerel caught with hook and line from boats, and landed in said boats, or in traps and weirs connected with the shore."

This enactment was intended especially to prohibit the capture of mackerel during the period noted by means of purse seins operated from American vessels. The following summary, from an able article on this subject by Dr. H. M. Smith,[a] shows the extent of this fishery during the three years immediately preceding the period to which this enactment applied and during the six years following:

STATEMENT SHOWING THE EXTENT OF THE AMERICAN PURSE-SEINE FISHERY FOR FRESH MACKEREL FROM MARCH 1 TO MAY 31, INCLUSIVE, DURING A SERIES OF YEARS.

Year.[a]	Vessels fishing.	Fresh mackerel landed.	
	Number.	*Number.*	*Value.*
1885	175	31, 250, 000	$273, 500
1886	150	2, 739, 370	78, 507
1887	105	3, 500, 000	86, 805
1893	60	200, 190	21, 000
1894	50	160, 550	10, 919
1895	38	121, 050	14, 261
1896	39	317, 000	41, 790
1897	84	1, 491, 255	107, 242
1898	44	102, 545	19, 764

[a] No fishing in 1888–1892, according to law.

From this summary it appears that practically no beneficial effect can be attributed to the enactment, the average annual yield in the three years preceding its enforcement being 12,496,457 fish, or 87,114 per vessel, while the average during the six years following the closed period was only 398,765 mack-

[a] The southern spring mackerel fishery, Bulletin United States Fish Commission, vol. XVIII, p. 270.

erel, or 7,596 per vessel employed. Those who favor restriction on the sea fisheries claim that the length of the closed season and the period of years which the restriction covered were too short for favorable results.

Other prominent enactments of a similar nature were the numerous herring restrictions in England, Scotland, and some of the continental countries, and especially the herring and mackerel protective regulations resulting from the Anglo-French convention of 1839. But it does not appear that these regulations had any effect whatever on the increase or the decrease of these migratory fishes, which seem to depend on such natural causes as fluctuations in food supply, the destruction of brood by storms, etc., and that the abundance of the fishes themselves can not be seriously affected by restrictive legislation so long as the present conditions of supply and demand exist.

Since this legislation interferes with the established uses and customs of the fishermen, the burden is upon those who advocate it to prove that the benefit will outweigh the inconvenience. Ever since the influential voice of Huxley was lifted in its defense,[a] the policy of unrestricted use of the migratory species has continued to grow. This view has been strongly supported by Prof. W. C. McIntosh in Great Britain, by Dr. Hjort and Dr. Dahl in Norway, by Prof. Baird, Dr. Goode, and Mr. Eugene Blackford[b] in America, and by many other eminent authorities.

So far as regards the demersal or bottom fishes—the cod, haddock, halibut, flatfish, etc.—our present knowledge of the remedial effects of fishery restriction is so slight as scarcely to furnish a satisfactory basis for even national legislation in territorial waters, much less for complicated international regulations. A review of these regulations already established shows that the arrangement of joint action is a tedious and difficult matter, and ratification of the convention is always uncertain. Indeed, except so far as concerns the police of the fisheries,

[a] "The best thing for governments to do in relation to the herring fisheries is to let them alone, except in so far as the police of the sea is concerned. With this proviso let people fish how they like, as they like, and when they like. There is not a particle of evidence that anything man does has an appreciable influence on the stock of herrings. It will be time to meddle when any satisfactory evidence that mischief is being done is produced." (Huxley, in Popular Science Monthly, August, 1881.)

And again: "Every legislative restriction means the creation of a new offense. In the case of fishery, it means that a simple man of the people, earning a scanty livelihood by hard toil, shall be liable to fine and imprisonment for doing that which he and his fathers before him have, up to that time, been free to do. If the general interest requires that this burden should be put upon the fishermen—well and good. But if it does not—if indeed there is any doubt about the matter, I think that the man who made the unnecessary law deserves a heavier punishment than the man who breaks it." (Huxley, "Inaugural Address," International Fisheries Exhibition (London), 1883.)

[b] In testifying before a United States Senate committee in 1886, the late Mr. Blackford, who was one of the best informed fish dealers this or any other country has produced, stated that formerly he had thought protection necessary for the mackerel and other ocean fishes, "but when I got my material all together, I found the facts were entirely opposite to the views which I had entertained, and the more I looked into the subject the more I became impressed that there was no necessity for legislation for the protection of any of the free-swimming open-sea fishes." (Bulletin United States Fish Commission, vol. XVIII, p. 212.)

it does not appear that great practical benefit has resulted from the regulations for preserving the fisheries on the high seas.

It is easy to exaggerate the evil effects of fishing on the bottom species. Nearly six centuries ago, in England under Edward III, there was an agitation against the use of beam trawls, and petitions in Parliament gave visions of the speedy and complete ruin of the fisheries unless the use of this form of apparatus was interdicted; and yet trawling has continued undiminished from that time; indeed, it has never been more extensive than in recent years, and the sea has continually repaired the loss.

In 1890 there was a conference of representatives of European nations to discuss the question of remedial measures for the preservation of the demersal fishes of the deep seas about Europe. This conference was held at London, under the auspices of the National Sea Fisheries Protective Association, and was attended by delegates from Belgium, Denmark, France, Germany, Great Britain, the Netherlands, and Spain. It was unofficial in the sense that the Governments were not bound by its conclusions, but the delegates were among the most prominent officials connected with the fishery service of their respective countries.

The conference had particular reference to some arrangement for saving the small or immature flatfish and especially those taken by means of beam or otter trawls.[a] The discussion related especially to the need for such action and to the particular species which required protection; also to the desirability for protecting the spawning fish and for reserving certain portions of the North Sea for breeding purposes, at least for a portion of the year.

There was a general consensus of opinion as to the desirability of restraint on the capture of undersized flatfish, but it was not found practicable to arrive at definite recommendation to the several Governments leading to an international agreement or arrangement. However, the following resolutions were adopted:

That this conference considers it desirable that an official international conference of European maritime powers should be held with the view of concluding a convention for the prohibition of the landing and sale of undersized flatfish within their respective jurisdictions.

This conference, moreover, considers it desirable that, before the official conference meets, the different nations interested in the sea fisheries of European waters will col-

[a] The chief proposals for dealing with the capture of immature fish were thus summarized by Sir Thomas Boyd, chairman of the Fishery Board for Scotland: (1) Simply to prevent the sale of fish under a fixed size, without in any way interfering with the mode of fishing or the place of fishing. The disadvantage is that such a measure would not prevent their capture and destruction, since they must be taken in the ordinary way of fishing; (2) besides prohibiting their sale, to make regulations with the object of preventing their capture or destruction, viz: (*a*) By closing certain areas where young fish are supposed to be especially abundant; (*b*) by enlarging the mesh of the nets and fixing by law a minimum size of mesh. This would be a useful measure, and would enable many immature fish to escape, but large numbers would still be retained; (*c*) by compelling trawlers and line fishermen to return undersized fish to the sea in such a condition that they would live.

lect, with as little delay as possible, sufficient information, scientific as well as statistical, with regard to the damage done by the capture of undersized fish by their fishermen.

That the National Sea Fisheries Protective Association be requested to formulate a set of questions with a view to obtaining scientific and statistical information in relation to undersized fish and forward it to each delegate, in order that he may submit it to his Government for adoption.

No international action has yet come of this conference, but several of the nations have acted independently in the matter and interdicted the sale of undersized fish.

The Belgian Government, by royal decree dated September 5, 1892, prohibited fish under certain sizes from being landed, transported, sold, or exposed for sale in Belgium, without distinction as to the place of capture (sans distinction de leur provenance) or as to the nationality of the boat which caught them. The sizes specified are 25 centimeters for turbot, brill, ray, halibut, cod, and haddock, and 18 centimeters for soles, dab, plaice, and whiting, these measurements covering the extreme length of the fish.

Somewhat similar provisions were enacted in Denmark by law of April 5, 1888.[a] The declaration of 1907, supplementary to the convention of 1899 between Sweden and Denmark, which restricted the capture and sale of plaice under a designated length, has already been noted at length in the discussion of that convention. Other states with undersize fish laws are France, Germany, Holland, Sweden, Norway with reference to lobsters, England with reference to lobsters and crabs, and many of the American states, especially with respect to crustaceans and mollusks.

The principal effect in Great Britain of the conference of 1890 was the appointment of a select committee in the House of Commons to consider the expediency of adopting measures for the preservation of the fisheries "in the seas around the British Islands, including the prohibition of the capture, landing, or sale of undersized sea fish, the prohibition of the sale or possession of certain sea fish during the periods when their capture is forbidden, the fixing of close seasons, the prohibition or regulation of certain methods of fishing, the protection of defined areas, and other like regulations, international or otherwise."

For the purpose of determining the best regulations for preserving the fishery resources with the maximum extent of their utilization, it is not easy to exaggerate the importance of systematic research in marine biology and the effect of fishing operations. Excellent work of this nature has been done and is yet in progress in many countries where the fisheries are of great extent.

[a] Section 15 of this law provided that no trade may be carried on in Bornholm salmon under 3 pounds, trout under one-half pound, cod under one-fourth pound, and turbot under one-half pound; and section 56 of the same law prohibited the purchase and sale of eels, pike, and salmon less than 12 inches; of cod, whiting, plaice, turbot, brill, bream, tench, trout, and gwiniad less than 8 inches; and of dab, flounder, perch, and bleak less than 6 inches measured from the point of the fore snout to the root of the caudal fin.

The sentiment favorable to this research has moreover surpassed the bounds of national jurisdiction and become international in its scope. Prominent among such investigations are those conducted by the Joint Commission—commonly known as the Rathbun-Wakeham Commission—appointed December 6, 1892, on behalf of the United States and Great Britain relative to the prevention of destructive methods of fishing and to the preservation of the fisheries in the waters contiguous to the United States and Canada. The interesting and valuable report of this commission, presented in 1896,[a] furnishes much practical data relative to the legislative needs of our border fisheries.

On April 11, 1909, a treaty was concluded between Great Britain and the United States for the purpose of arranging uniform regulations in these waters; and a thorough examination of the present condition and needs of these fisheries is now being made by Dr. David S. Jordan, assisted by Dr. Barton W. Evermann, on the part of the American Government, and by Prof. E. E. Prince, who succeeded Mr. S. T. Bastedo, on the part of the British Government. The report of these commissioners, to be made in June, 1909, is awaited with much interest, and it is hoped that favorable action thereon will result in great benefit to the fishery interests of both Canada and the United States.

Even more extensive are the joint investigations now in progress in the seas north of Europe. In 1899 the Government of Sweden extended to the nations prominently interested in those fisheries an invitation to attend a conference for the purpose of uniting on some plan of international research. This resulted in a gathering at Stockholm in June, 1899, of representatives from Great Britain, Germany, Russia, Denmark, the Netherlands, Norway, and Sweden. A second conference of representatives of the same powers was held in May, 1901, at Christiana on invitation of the Norwegian Government. The result of these conferences was the recommendation of a scheme of investigation to the attention of the states interested. This scheme was accepted by each of these nations, and the several legislatures appropriated a sum of money for inaugurating the work. At a conference in Copenhagen in July, 1902, representatives of the contributing states established the "International Council for the Exploration of the Sea." This international research is yet in progress, and the results already obtained fully justify its establishment.

However we may view the protective needs of the migratory and the demersal fishes, the situation is quite different with respect to the sea mammals—the seals, walrus, manatees, sea otters, and many species of whales. These animals are approaching practical exhaustion with great rapidity, and prompt action seems necessary if they are to be reserved from extinction. This is not the language of exaggeration. Under the influence of the bounty which industrial use offers of $40 for the life of a fur seal, $300 for a sea otter, and $5,000 for an arctic whale, these animals are passing away far more rapidly than is generally

[a] H. Doc. 315, 54th Cong., 2d sess.

realized, the entire annual product of sea otters throughout the world now approximating only 200 and of the arctic whales less than 100 each year. The timid whalebone whales have been swept from the navigable seas and are nowhere to be found except in the most remote ice fields of the frigid zones, the recent decrease having been in geometric ratio owing to modern inventions—to steam vessels, electric lights, and especially to the shot harpoon. The walrus are almost exterminated in the seas north of Europe, and in Bering Sea, where they were formerly so plentiful, they are to be found only in one small herd, which hauls out in the spring and falls on the islets off Port Heiden, on the Alaska peninsula.

It is shocking to contemplate the indifference with which the civilized world has witnessed, nay, not only witnessed but encouraged, the slaughter, almost to the point of extinction, of highly organized animals evidencing traits of affection and devotion which would do honor to human beings. Everywhere, in every sea, it is the same story, slaughter, slaughter, slaughter. What more pathetic sight in the whole range of man's ruthless destruction than the thousands of nursing fur seals starving and dead at the present moment on the shores of the Pacific islands as a result of the inhuman butchery of their nurture-seeking mothers in the waters of Bering Sea and the North Pacific. At the present rate of decrease the day is not far distant when these will have become as extinct as the buffalo of the American prairies.

Let it not be understood that our sympathy for the highly organized creatures of the sea would withhold them from industrial use. The slaughter of animals under proper conditions, whether they be in the seas or under domestic care, does not in itself constitute needless cruelty, for the end of every individual, beast or human, is pathetic, whether it be brought about by sudden accident or through the waste of years. When this slaughter is so conducted that it is conservative utilization, with due care for the welfare and perpetuation of the species as a whole, it is but the most intelligent application of nature's wisest law of the survival of the fittest. The preservation which we would extend to these animals is largely for the purpose of their greater slaughter. We would surround them with such protection and take them only under such conditions as would tend to increase their numbers and thus make them of far greater value to the hardy fishermen whose industry has won renown in all ages.

It is hoped that the wide public interest attracted to the preservation of our natural resources will result in preventing the now imminent extermination of these species, whose zoologic and philosophic worth far exceeds their economic value; and it seems that this Fishery Congress faces no more important duty than that of adding the weight of its great influence in staying the inhuman hand of destruction and extermination. Already this subject is attracting attention in America, and during the last twelve months resolutions favoring action for the preservation of these animals were adopted by a number of scientific

societies, including the New York Zoological Society, the American Society of Vertebrate Paleontologists, and the American Society for the Advancement of Science. These resolutions were closely similar. That of the last-named society was as follows:

Resolved, That the American Society for the Advancement of Science will aid in any way practicable those measures legislative, international and local, which will prevent the now imminent extermination of the great marine vertebrates, especially the cetaceans and manatees, seals, green and other turtles on the coasts of the United States, or on the high seas.

It is beyond the limits of this paper to outline the proper direction of the efforts to preserve these resources. But in view of the fact that the fisheries on the high seas represent the greatest economic resource which the nations of the world hold in common for their joint use, it seems that there might be wisdom in a general treaty or international union for their consideration. Already there are several treaties of this nature with special international offices for the purpose of satisfying economic and other nonpolitical interests, such as the Universal Postal Union, established in 1874, the Union for the Protection of Industrial Property in 1883, and the Union for the Protection of Works of Literature and Art in 1886. More closely allied to our subject is the convention in behalf of the preservation of wild animals, birds, and fish in Africa, which was signed in London on May 19, 1900,[a] by France, Germany, Great Britain, Italy, Portugal, Spain, and the Kongo Free State.

And in this gathering of representatives from so many powerful states, what subject more worthy of consideration than the economic conservation of the resources of the seas. A brotherhood of great nations arranging not the partition of nature's inheritance among themselves for speedy waste and despoilment, but the preservation of that inheritance for beneficial use in common by all the people of the earth; each to draw upon that storehouse of wealth only in accordance with the common welfare of all, for the sustenance of its citizens, for the comfort of its people, and for the advancement of civilization throughout the world.

[a] See Martens, Nouveau Recueil Général de Traités et autres Actes relatifs aux Rapports de Droit international. Deuxième série, t. xxx, p. 430.

APPENDIXES.

APPENDIX A.

Regulations for the Guidance of the fishermen of Great Britain and of France, in the seas lying between the coasts of the two countries; prepared in pursuance of the provisions of the eleventh Article of the Convention concluded at Paris on the 2d of August, 1839, between Her Majesty and the King of the French.

ARTICLE I. British and French subjects fishing in the seas lying between the coasts of the United Kingdom of Great Britain and Ireland and those of the Kingdom of France shall conform to the following Regulations.

ART. II. The limits within which the general right of fishery is exclusively reserved to the subjects of the two Kingdoms respectively are fixed (with the exception of those in Granville Bay) at three miles distance from low-water mark.

With respect to bays the mouths of which do not exceed ten miles in width, the three-mile distance is measured from a straight line drawn from headland to headland.

ART. III. The miles mentioned in the present Regulations are geographical miles, of which sixty make a degree of latitude.

ART. IV. The fishery limits of Granville Bay, established upon special principles, are defined in the first Article of the Convention of the second of August, one thousand eight hundred and thirty-nine, as follow:

The lines drawn between the points designated by the letters A, B, C, D, E, F, G, H, I, K, on the chart annexed to the Convention are acknowledged as defining the limits between which and the French shore the oyster fishery shall be reserved exclusively to French subjects; and these lines are as follow; that is to say:—

The first line runs from the point A, three miles from low-water mark (Point Meinga bearing south), to the point B, of which the landmarks are Agon Tower on with the clump of trees upon Mount Huchon, and the summit of Gros Mont in a line with the signal post on Grand Isle.

The second line runs from the said point B, towards Agon Tower and the clump of trees upon Mount Huchon in the direction north, sixty-four degrees east, until at the point C it brings the windmill of Lingreville to bear due east.

The third line runs from point C, due east towards Lingreville windmill until the Grand Huguenant is brought to bear on the Etat Rock at point D.

The fourth line runs from point D northward, and keeping the Grand Huguenant in one with the Etat Rock, until it intersects at E a line whose landmarks are Agon Tower on with Coustances cathedral.

The fifth line runs eastward from point E to point F, where the steeple of Pirou is brought to bear in a line with the Senequet Rock.

The sixth line runs from point F due north to point G, where the steeple of Blainville is brought in a line with the Senequet Rock.

The seventh line runs from point G (in the direction of Pirou steeple) to point H, where the light-house on Cape Carteret bears north, twenty-four degrees west.

The eighth line runs from point H to point I, nearly abreast of Port Bail; point I having for landmarks the fort of Port Bail in a line with the steeple of Port Bail.

And finally, the ninth line runs from point I to the Three Grunes at point K, where Cape Carteret bears east, ten degrees north, in a line with Barneville church.

All the bearings specified in the present Article are to be taken according to the true meridian and not according to the magnetic meridian.

ART. V. It is forbidden to British fishermen to set their nets or to fish in any manner whatever within the French limits; and it is equally forbidden to French fishermen to set their nets or to fish in any manner whatsoever within the British limits.

ART. VI. All British and French fishing boats shall be numbered.

There shall be a series of numbers for the fishing boats belonging to each Collectorship of Customs in the United Kingdom, and a series of numbers for the fishing boats belonging to each district of Maritime Registry in France; and to these numbers shall be prefixed the initial letters of the names of the respective collectorships or districts.

ART. VII. Whereas there are in the United Kingdom several Collectorships of Customs, and in France several districts of Maritime Registry, the names of which begin with the same letter, in which case the initial letter alone would not suffice; the distinguishing letter or letters for the boats of each collectorship or district shall be designated by the Board of Customs in the United Kingdom and by Ministry of Marine in France.

ART. VIII. The letters and numbers shall be placed on each bow of the boat, three or four inches (eight or ten centimètres French) below the gunnel, and they shall be painted in white oil colour, on a black ground.

For boats of fifteen tons burthen and upward the dimensions of these letters and numbers shall be eighteen inches (forty-five centimètres French) in height, and two and a half inches (six centimètres French) in breadth.

For boats of less than fifteen tons burthen, the dimensions shall be ten inches (twenty-five centimètres French) in height, and one and three-quarter inches (four centimètres French) in breadth.

The same letters and numbers shall also be painted on each side of the mainsail of the boat in black oil colour on white sails, and in white oil colour on tanned or black sails.

These letters and numbers on the sails shall be one-third larger in every way than those placed on the bows of the boat.

ART. IX. In order that the fishing boats of Jersey, Guernsey, and other islands of the same cluster may be distinguished from the fishing boats of the other British islands their numbers shall precede the initial letter of the name of the island to which such boats may belong.

Each of these islands shall have a separate series of numbers.

ART. X. All the buoys, barrels, and principal floats of each net, and all other implements of fishery shall be marked with the same letters and numbers as those of the boats to which they belong.

These letters and numbers shall be large enough to be easily distinguished. The owners of nets or other fishing implements may further distinguish them by any private marks they judge proper.

ART. XI. The letters and numbers of British fishing boats shall be inserted on the licenses of those boats, after having been entered in the Registry book kept at the Collectorship of Customs.

The letters and numbers of French fishing boats shall be inserted on the muster rolls of those boats, after being entered in the Registry book kept at the Maritime Registry office.

ART. XII. The licences of British fishing boats and the muster rolls of French fishing boats shall contain the description and tonnage of each boat, as well as the names of its owner and of its master.

ART. XIII. The fishermen of both countries shall, when required, exhibit their licences or muster rolls to the commanders of the fishing cruisers, and to all other persons of either country appointed to superintend the Fisheries.

ART. XIV. The name of each fishing boat and that of the port to which she belongs shall be painted in white oil colour on a black ground on the stern of the said boat, in letters which shall be at least three inches (eight centimètres French) in height and half an inch (twelve millimètres French) in breadth.

ART. XV. It is forbidden to efface, cover, or conceal, in any manner whatsoever, the letters, numbers, and names placed on the boats and on their sails.

ART. XVI. Trawl fishing may be carried on during all seasons in the seas lying between the fishery limits which have been fixed for the two countries.

ART. XVII. Trawls shall be made with nets, the meshes of which shall be at least one inch and three quarters (forty-five millimètres French) square, from knot to knot, along the line.

ART. XVIII. The length of the wooden yard or beam to which the upper part of the mouth of each trawl net shall be fastened shall not exceed thirty-eight feet (eleven mètres five hundred millimètres French).

ART. XIX. The underpart of the trawl net, to a length of ten feet (three mètres French) from its extremity, may be strengthened by rubbing pieces made of old nets; but these rubbing pieces shall be so fastened that they shall not cross or narrow the meshes of the trawl net, which must always remain at least one inch and three quarters (forty-five millimètres French) from knot to knot, along the line, open and unobstructed.

ART. XX. The size of the meshes of any supplementary nets which may be added to trawls shall be at least two inches (fifty millimètres French) square from knot to knot, along the line.

ART. XXI. Such supplementary nets shall be so fitted as not to cross or narrow the meshes of the trawl net, which must always remain at least one inch and three quarters (forty-five millimètres French) from knot to knot, along the line, open and unobstructed.

ART. XXII. The total weight of the two irons or headpieces of a trawl shall not exceed two hundred and eighty-seven pounds (one hundred and thirty kilograms French).

ART. XXIII. The total weight of iron chains or leads used for loading the ground rope of a traw shall not exceed one hundred and ten pounds (fifty kilograms French).

ART. XXIV. Trawl fishing is forbidden in all places where there are boats engaged in herring or mackerel drift-net fishing.

ART. XXV. Trawl boats shall always keep at a distance of at least three miles from all boats fishing for herring or mackerel with drift nets.

ART. XXVI. Whenever herring or mackerel boats shall commence drift-net fishing in any place whatever, the trawl boats which may be already fishing in such place shall depart therefrom, and shall keep at a distance of at least three miles from the said drift-net herring or mackerel boats.

ART. XXVII. Herring fishing is free all the year round.

ART. XXVIII. The meshes of all nets used for herring fishing shall not be less than one inch (twenty-five millimètres French) square from knot to knot, along the line.

ART. XXIX. Whenever decked herring boats and undecked herring boats shall commence shooting their nets at the same time, the undecked boats shall shoot their nets to windward of the decked boats, except they should prefer going to leeward, to a distance of at least half a mile, to shoot their nets.

ART. XXX. The decked boats on their part shall shoot their nets to leeward of the undecked boats, unless they prefer going to windward, to a distance of at least half a mile, to shoot their nets.

ART. XXXI. When decked boats shall arrive on grounds where fishing is already begun by other boats, among which shall be undecked boats, the decked boats so arriving shall shoot their nets to leeward of the undecked boats, except they should prefer going to windward, to a distance of at least half a mile, to shoot their nets.

ART. XXXII. When undecked boats shall arrive on grounds where fishing is already begun by other boats, among which shall be decked boats, the undecked boats so arriving shall shoot their nets to windward of the decked boats, except they prefer going to leeward, to a distance of at least half a mile, to shoot their nets.

ART. XXXIII. If, however, it should happen that the spot where fishing is going on, and consequently where the herrings are, should be so near to the fishery limits of one of the two countries, that the boats of the other country would, by observing the above mentioned Regulations, be prevented from taking part in the fishery, the said boats of the other country shall be at liberty to shoot their nets at a less distance than that prescribed in the preceding Articles for decked and undecked boats; but such fishermen as may take advantage of this permission shall be responsible for any damage or losses which their drifting may cause to the other boats.

ART. XXXIV. Fishermen of the one country shall not avail themselves of the circumstances mentioned in the preceding Article, nor of any other circumstances whatsoever, to shoot their nets within the fishery limits of the other country.

ART. XXXV. Whenever set nets are employed for the purpose of taking herrings, the boats engaged in this fishery shall always remain over their nets.

These boats shall, moreover, be bound to observe the prohibition contained in Article LVII in favor of drift-net fishing.

ART. XXXVI. Mackerel fishing is free all the year round.

ART. XXXVII. The meshes of all nets used for mackerel fishing shall not be less than one inch and one-sixth (thirty millimètres French) square, from knot to knot, along the line.

ART. XXXVIII. It is forbidden to all fishermen to load the lower parts of mackerel drift nets with leads or stones.

ART. XXXIX. Boats going to fish for mackerel with drift nets are required, when they shall arrive on the fishing ground, to lower all sails, to show that they have taken their berths.

ART. XL. The boats mentioned in the preceding article shall keep three-quarters of a mile at least apart from one another when they shoot their nets.

ART. XLI. The meshes of nets known by the name of bratt nets shall not be less than four inches and one-third (eleven centimètres French) square, from knot to knot, along the line.

ART. XLII. The meshes of the middle nets of trammels shall be at least two inches (five centimètres French) square, from knot to knot, along the line.

The meshes of both of the outer nets of trammels shall be at least six inches (fifteen centimètres French) square, from knot to knot, along the line.

ART. XLIII. Fishermen using bratt nets, trammels, and other set or anchored nets, shall place buoys on such nets, in order that vessels sailing in those places may avoid them.

ART. XLIV. Such bratt nets, trammels, or other set or anchored nets shall not, except in unavoidable cases, remain more than twenty-four hours in the sea without being taken up.

ART. XLV. Oyster fishing shall open on the first of September, and shall close on the thirtieth of April.

ART. XLVI. From the first of May to the thirty-first of August no boat shall have on board any dredge or other implement whatsoever for catching oysters.

ART. XLVII. It is forbidden to dredge for oysters between sunset and sunrise.

ART. XLVIII. The fishermen shall cull the oysters on the fishing ground, and shall immediately throw back into the sea all oysters less than two and a half inches (six centimetres French) in the greatest diameter of the shell, and also all sand, gravel, and fragments of shells.

ART. XLIX. It is forbidden to throw into the sea on oyster fishing grounds the ballast of boats, or any other thing whatsoever which might be detrimental to the oyster fishery.

ART. L. For the purpose of distinguishing by day drift-net fishing boats from trawl boats, both shall carry at the masthead vanes, which shall be at least eight inches (twenty centimètres French) in height and two feet (sixty-one centimètres) in length.

The colours of these vanes shall be, for—

British trawl boats, red.
French trawl boats, blue.
British drift boats, white and red.
French drift boats, white and blue.

It is understood that the vanes of drift boats shall be divided vertically into two equal parts, of which the white shall be nearest to the mast.

ART. LI. It is forbidden to all other fishing boats to carry vanes similar to those mentioned in the preceding Article.

ART. LII. It is forbidden to all boats to anchor between sunset and sunrise on grounds where herring or mackerel drift-net fishing is going on.

This prohibition does not apply to anchorages which may take place in consequence of accidents or any other compulsory circumstances, but in such case the master of the boat thus obliged to anchor shall hoist, so that they shall be seen from a distance, two lights placed horizontally about three feet (one mètre French) apart, and shall keep these lights up all the time the boat shall remain at anchor.

ART. LIII. In order that boats fishing with drift nets may be easily recognized at night, the masters of these boats shall hoist on one of their masts two lights, one over the other, three feet (one mètre French) apart.

These lights shall be kept up during all the time their nets shall be in the sea between sunset and sunrise.

ART. LIV. All fishermen are forbidden, except in cases of absolute necessity, to show lights under any other circumstances than those mentioned in the present Regulations.

ART. LV. The meshes of the various nets before mentioned shall be of the prescribed dimensions, measured when the net is wet.

ART. LVI. It is forbidden to use nets for any other kind of fishing than that for which each of those nets may be lawfully employed, with respect to the size of its meshes, or of its fittings.

ART. LVII. It is forbidden to set or anchor nets, or any other fishing implement, in any place where herring or mackerel drift-net fishing is going on.

ART. LVIII. No boat shall be made fast or held on to the nets, buoys, floats, or to any part of the fishing tackle belonging to another boat.

ART. LIX. It is forbidden to all persons to hook or lift up the nets, lines, or other fishing implements belonging to others, under any pretence whatsoever.

ART. LX. When nets of different boats get foul of each other, the masters of the said boats shall not cut them, except by mutual consent, unless it shall have been found impossible to clear them by other means.

ART. LXI. All fishing boats, all rigging, gear, or other appurtenances of fishing boats, all nets, buoys, floats, or other fishing implements whatsoever, found or picked up at sea, shall, as soon as possible, be delivered to the Collector of Customs, if the article saved be taken into England, and to the Commissary of Marine, if the article saved is taken into France.

ART. LXII. The Collector of Customs, or the Commissary of Marine, as the case may be, shall restore the articles saved to the owners thereof or to their representatives.

These functionaries may, when the circumstances are such as to call for it, award to the salvors a suitable compensation for their trouble and care. This compensation, which shall in no case exceed one-fourth of the actual value of the articles saved, shall be paid by the owners.

ART. LXIII. The execution of the regulations concerning the fittings of nets and the size of their meshes, the weight and dimensions of fishing instruments, and, in short, concerning every thing connected with the implements of fishing, is placed, with respect to the fishermen of each of the two nations, under the exclusive superintendence of the cruisers and agents of their own nation.

Nevertheless the Commanders of the cruisers of each nation shall mutually acquaint the Commanders of the other nation with any transgressions of the above-mentioned regulations, committed by the fishermen of the other nation, which may come to their knowledge.

ART. LXIV. Infractions of regulations concerning the placing of boats, the distances to be observed, the prohibition of certain fisheries by day or by night, or during certain periods of the year, and concerning every other operation connected with the act of fishing, and more particularly as to circumstances likely to cause damage, shall be taken cognizance of by the cruisers of both nations, whichever may be the nation to which the fishermen guilty of such infractions may belong.

ART. LXV. The commanders of cruisers of both countries shall exercise their judgment as to the causes of any transgressions committed by British or French fishing boats in the seas where the said boats have the right to fish in common; and when the said Commanders shall be satisfied of the fact of the transgression, they shall detain the boats having thus infringed the established Regulations, and may take them into the port nearest to the scene of the occurrence, in order that the offense may be duly established, as well by comparing the declarations and counter declarations of parties interested, as by the testimony of those who may have witnessed the facts.

ART. LXVI. When the offence shall not be such as to require exemplary punishment, but shall, nevertheless, have caused injury to any fisherman, the Commanders of cruisers shall be at liberty, should the circumstances admit of it, to arbitrate at sea between the parties concerned, and on refusal of the offenders to defer to their arbitration, the said Commanders shall take both them and their boats into the nearest port, to be dealt with as stated in the preceding Article.

ART. LXVII. Every fishing boat which shall have been taken into a foreign port, under either of the two preceding Articles, shall be sent back to her own country for trial as soon as the transgression for which she may have been detained shall have been duly established. Neither the boat nor her crew shall, however, be detained in the foreign port more than four days.

ART. LXVIII. The depositions, minutes of proceedings, and all other documents concerning the transgression, after being authenticated by the Collector of Customs, or by the Commissary of Marine according to the country into which the boat may have been taken, shall be transmitted by that functionary to the Consular Agent of his nation residing in the port where the trial is to take place.

This Consular Agent shall communicate these documents to the Collector of Customs, if in the United Kingdom, or to the Commissary of Marine, if in France; and if, after having conferred with that functionary, it shall be necessary for the interest of his countrymen, he shall proceed with the affair before the competent tribunal or magistrates.

ART. LXIX. All transgressions of these Regulations established for the protection of Fisheries in the seas lying between the coasts of the British islands and those of France shall, in both countries, be submitted to the exclusive jurisdiction of the tribunal or the magistrates which shall be designated by law.

This tribunal, or these magistrates, shall also settle all differences, and decide all contentions, whether arising between fishermen of the same country, or between fishermen of the two countries, and which can not have been settled by the Commanders of cruisers, or by the Consular Agents and the Collectors of Customs, or Commissaries of Marine, according to the country.

The above-mentioned jurisdiction shall not, however, be understood to apply to murder, felony, or any other grave crime; all such crimes remaining subject to the ordinary laws of each country, respectively.

ART. LXX. The trial and judgment of the transgressions mentioned in the preceding Article shall always take place in a summary manner, and at as little expense as possible.

ART. LXXI. In both countries the competent tribunal or magistrates shall be empowered to adjudge the following penalties for offenses against the Regulations committed by fishermen subject to their jurisdiction:

First. Forfeiture and destruction of nets or other fishing implements which are not conformable to the Regulations.

Secondly. Fines from eight shillings (ten francs) to ten pounds sterling (two hundred and fifty francs), or imprisonment for not less than two days, and not more than one month.

ART. LXXII. The use of nets or other fishing implements of which the fittings, size of meshes, dimensions, or weight shall not be conformable to the Regulations established for each kind of Fishery shall subject the said nets or implements to seizure and destruction, and the offenders to a fine of not less than eight shillings (ten francs) nor more than three pounds sterling (seventy-five francs), or to imprisonment from two to ten days.

In cases of repetition of the offence, the fine or imprisonment may be doubled.

ART. LXXIII. All persons shall be condemned to a fine of from eight shillings to five pounds sterling (ten francs to one hundred and twenty-five francs), or to imprisonment from five to fifteen days, who either by night or by day, conjointly or separately, shall offend against the measures established by the Regulations for the preservation of peace and good order, and specifically against those concerning—

First. The letters, numbers, and names to be placed on the boats and their sails, and on nets, buoys, etc.

Secondly. The vanes to be carried by the boats.

Thirdly. The distances to be observed between the boats.

Fourthly. The placing and anchoring of boats.

Fifthly. The placing or shooting of nets, and taking them up.

Sixthly. The clearing of nets.

Seventhly. The placing of buoys upon nets.

Eighthly. Lastly, the lights to be shown.

In cases of repetition of any of these offences, the fine or imprisonment may be doubled.

ART. LXXIV. In all cases of assault committed at sea by fishermen on other fishermen, or whenever they shall have intentionally caused damages or loss, the competent tribunal or magistrates may condemn the delinquents to a term of imprisonment not exceeding twenty days, or to a fine not exceeding five pounds sterling (one hundred and twenty-five francs).

Should there have been at the same time any infringement of the Regulations, the imprisonment or fine above mentioned may be awarded over and above the penalties to which the said infringement shall have given rise.

ART. LXXV. The competent tribunal or magistrates shall, when the circumstances are such as to call for it, award, over and above all penalties inflicted for offences against the Regulations, the payment of damages to the injured parties, and shall determine the amount of such damages.

ART. LXXVI. The conditions under which the fishing boats of either of the two countries shall be at liberty to come within the fishery limits of the other country are laid down in the following Articles, which also specify and regulate the penalties to be inflicted for infraction of the said Articles.

ART. LXXVII. The competent tribunal or magistrates shall exclusively take cognizance (in the same manner as stipulated in Article LXIX) of the infractions mentioned in Article LXXVI.

ART. LXXVIII. The putting into the Chausey Islands by British oyster fishing boats is regulated by the six following Articles.

ART. LXXIX. The putting into the Chausey Islands by British fishing boats, in consequence of damage, evident bad weather, or any other compulsory circumstance, is a right confirmed by Article VII of the convention of the second of August, one thousand eight hundred and thirty-nine.

ART. LXXX. The expediency of putting in, under any of the circumstances mentioned in the preceding Article, must naturally be determined by those fishermen who may find it necessary to avail themselves of this right.

Nevertheless, whenever the British fishing boats shall be able to communicate with the Commander of the British station, they shall not put in until they are authorised so to do by the said Commander's hoisting the following signal—a blue ensign at the masthead.

ART. LXXXI. The Commander of the English station may, when he shall consider this measure necessary, authorise the weaker boats, which are consequently the most exposed to the effects of bad weather, to put into the Chausey Islands whilst the other boats shall continue to fish.

This permission shall be made known by the following signal—a red ensign at the masthead.

ART. LXXXII. When the Commander of the English station shall have authorised the whole or part of the British boats to seek shelter in the Chausey Islands, in consequence of the above-mentioned causes, he shall give notice thereof immediately afterwards to the French cruisers by means of the following signals, viz:

For the anchorage of all the boats (provided for in Article LXXX), a blue peter placed under the blue ensign at the masthead.

For the anchorage of the weaker boats (provided for in Article LXXXI), a blue peter placed under the red ensign at the masthead.

ART. LXXXIII. Whenever the appearance of the weather, although it be not actually stormy at the time, yet shall be so threatening that boats could not gain shelter of the British Channel Islands before it comes on, the British Commander, taking on himself the responsibility of the measure, may authorize the said boats to anchor at Chausey, by hoisting a blue peter.

This permission shall, at the same time, be made known to the French cruisers by means of a French flag hoisted at the masthead over the said blue peter.

These flags shall not be hauled down until the French cruisers shall have understood the signal, and answered it by hoisting, also at the masthead, an English flag.

ART. LXXXIV. When British fishing boats put into Chausey, they shall keep together in the same part of the anchorage.

Should any compulsory circumstances prevent their doing so, the Commander of the English station shall inform the French station thereof by hoisting, in addition to the flags flying to announce the putting in of the boats, a Union Jack under the said flags.

ART. LXXXV. The fishing boats of the one country shall not approach nearer to any part of the coasts of the other country than the limit of three miles, specified in Article IX of the convention signed at Paris on the second day of August, one thousand eight hundred and thirty-nine, except under the following circumstances:

First. When driven by stress of weather or by evident damage to seek shelter in the harbours, or within the fishery limits of the other country.

Secondly. When carried within the limits established for the fishery of the other country by contrary winds, by strong tides, or by any other cause independent of the will of the master and crew.

Thirdly. When obliged by contrary winds or tide to beat up in order to reach their fishing ground; and when, from the same cause of contrary wind or tide, they could not, if they remained outside, be able to hold on their course to their fishing ground.

Fourthly. When during the herring fishing season, the herring fishing boats of one country shall find it expedient to anchor under shelter of the coasts of the other country, in order to await a favourable opportunity for proceeding to their lawful fishery outside of the limits defined by Article IX of the Convention of the second of August, one thousand eight hundred and thirty-nine.

ART. LXXXVI. Whenever, in any of the cases of exception specified in the preceding Article, the fishing boats of either nation shall have occasion to sail or anchor within the limits defined by the Convention of the second of August, one thousand eight hundred and thirty-nine, the masters of such boats shall immediately hoist a blue flag, two feet high and three feet long, and shall keep this flag flying at the masthead so long as they shall remain within the said limits; consequently this flag shall not be hauled down until the boats are actually outside of those limits.

These boats, when within the aforesaid limits, are not only prohibited from fishing themselves, but are also forbidden to send their small boats to fish, even outside of the limits in question. They must all (with the exception of herring boats, which may be waiting, as they have the privilege of doing, for a favourable opportunity to proceed to their lawful fishery) return outside the said limits so soon as the causes shall have ceased which obliged them to come in under the cases of exception specified.

It is further agreed, conformably to the tenor of the present Regulations, that the fishing boats of the one country shall not use the ports of the other country for the greater convenience of their fishery operations, either in proceeding from thence to their lawful fishery in the seas common to both, or in returning thereunto after fishing; it being understood, however, that this stipulation does not in any manner impair the right of putting into port in the cases of exception specified in Article LXXXV.

ART. LXXXVII. It is forbidden to herring drift-net fishing boats to shoot their nets earlier in the day than half an hour before sunset, except in places where it is customary to carry on this drift-net fishing by daylight.

ART. LXXXVIII. Herring fishermen, being within the fishery limits of either country, shall comply with the laws and regulations of the said country respecting the prohibition of fishing on the Sabbath day.

ART. LXXXIX. The Commanders of the cruisers of each of the two countries, and all officers or other agents whatsoever appointed to superintend the fisheries, shall exercise their judgment as to the causes of any transgressions committed by the fishing boats of the other country, and when they shall be satisfied of the fact of the transgression, they shall detain or cause to be detained the boats having thus transgressed the preceding Regulations (from Article LXXVI), and shall take them or cause them to be taken into port, where, upon clear proof of the transgression being brought by the detaining party before the competent tribunal or magistrates, the said boats so transgressing may be condemned to be kept for a period not exceeding three months, or to a fine not exceeding ten pounds sterling (two hundred and fifty francs).

In testimony whereof the respective Commissioners have signed the present Regulations, and have thereto affixed their seals.

Done in London the twenty-fourth day of May in the year of our Lord one thousand eight hundred and forty-three.

APPENDIX B.

Convention between Her Majesty and the Emperor of the French relative to fisheries in the seas between Great Britain and France.

ARTICLE I. British fishermen shall enjoy the exclusive right of fishery within the distance of three miles from low-water mark, along the whole extent of the coasts of the British islands; and French fishermen shall enjoy the exclusive right of fishery within the distance of three miles from low-water mark along the whole extent of the coast of France, the only exception to this rule being that part of the coast of France which lies between Cape Carteret and Point Meinga.

The distance of three miles fixed as the general limit for the exclusive right of fishery upon the coasts of the two countries shall, with respect to bays, the mouths of which do not exceed ten miles in width, be measured from a straight line drawn from headland to headland.

The miles mentioned in the present Convention are geographical miles, whereof sixty make a degree of latitude.

ART. II. It is agreed that the lines drawn between the points designated by the letters A, B, C, D, E, F, G, H, I, K, on the chart annexed to the present Convention, and signed by the respective Plenipotentiaries, shall be acknowledged by the high contracting parties as defining from Point Meinga

to Cape Carteret, the limits between which and the French shore the right of fishery shall be reserved exclusively to French fishermen, and these lines are as follows, that is to say:

The first line runs from the point A, three miles from low-water mark (Point Meinga bearing south) to the point B, of which the landmarks are Agon Tower on with the clump of trees upon Mount Huchon, and the summit of Gros Mont in a line with the semaphore on Grand Isle.

The second line runs from the said point B toward Agon Tower and the clump of trees upon Mount Huchon, in the direction north sixty-four degrees east, until, at the point C, it brings the windmill of Lingreville to bear due east.

The third line runs from point C due east toward Lingreville windmill, until the Grand Huguenant is brought to bear on the Etat Rock at point D.

The fourth line runs from point D northward (keeping the Grand Huguenant in one with the Etat Rock) until it intersects at E a line whose landmarks are Agon Tower on with Coustances Cathedral.

The fifth line runs eastward from point E to point F, where the steeple of Pirou is brought to bear in a line with the Senequet Light-house.

The sixth line runs from point F due north to point G, where the steeple of Blainville is brought in a line with the Senequet Light-house.

The seventh line runs from point G in the direction of Pirou Steeple to point H, where the light-house on Cape Carteret bears north twenty-four degrees west.

The eighth line runs from point H to point I nearly abreast of Port Bail; point I having for landmarks the fort of Port Bail in a line with the steeple of Port Bail.

And finally, the ninth line runs from point I to the Three Grunes at point K, where Cape Carteret bears east ten degrees north, in a line with Barneville Steeple.

It is further agreed that all the bearings specified in the present Article are to be taken according to the true meridian, and not according to the magnetic meridian.

ART. III. The arrangements of the present Convention shall apply beyond the fishery limits of both countries, as defined by the preceding Articles, to the seas surrounding and adjoining Great Britain and Ireland, and adjoining the coasts of France between the frontiers of Belgium and Spain. The rules respecting oyster fishery shall, however, be observed only in the seas comprised within the limits hereinafter described.

ART. IV. All British and French fishing boats shall be lettered and numbered. In the United Kingdom there shall be a series of numbers for the fishing boats belonging to each collectorship of Customs and in France a series of numbers for the fishing boats belonging to each district of Maritime Registry; and to these numbers shall be prefixed a letter (or letters) to be designated by the Board of Customs in the United Kingdom and by the Ministry of Marine in France.

ART. V. The letter (or letters) and numbers shall be placed on each bow of the boat, 3 or 4 inches (8 or 10 centimètres French) below the gunwale, and they shall be painted in white oil colour on a black ground.

For boats of 15 tons burthen and upwards the dimensions of the letters and numbers shall be 18 inches (45 centimètres French) in height and 2½ inches (6 centimètres French) in breadth.

For boats of less than 15 tons burthen the dimensions shall be 10 inches (25 centimètres French) in height and 1¾ inches (4 centimètres French) in breadth.

The same letter (or letters) and number shall also be painted on each side of the mainsail of the boat, in black oil colour on white sails, and in white oil colour on tanned or black sails. Such letter (or letters) and number on the sails shall be one-third larger in every way than those placed on the bows of the boat.

The name of each fishing boat and that of the port to which she belongs shall be painted in white oil colour on a black ground on the stern of the boat, in letters which shall be at least 3 inches (8 centimètres French) in height and one-half inch (12 millimètres French) in breadth.

The letters, numbers, and names placed on the boats and on their sails shall not be effaced, covered, or concealed in any manner whatsoever.

ART. VI. All the buoys, barrels, and principal floats of each net, and all other implements of fishery, shall be marked with the same letter (or letters) and number as those of the boats to which they belong.

These letters and numbers shall be large enough to be easily distinguished. The owners of the nets or other fishing implements may further distinguish them by any private marks they judge proper.

ART. VII. The letters and numbers of British fishing boats shall, after having been entered in the registry book kept at the collectorship of Customs, be inserted on the licences or other official papers of those boats.

The letters and numbers of French fishing boats shall, after having been entered in the registry book kept at the Maritime Registry Office, be inserted on the muster rolls of those boats.

ART. VIII. The licences or other official papers of British fishing boats, and the muster rolls of French fishing boats, shall contain the description and tonnage of each boat, as well as the names of its owner and of its master.

ART. IX. The fishermen of both countries shall, whenever required, exhibit their licences or other official papers, or their muster rolls, to the commanders of the fishery cruizers, and to all other persons of either country appointed to superintend the fisheries.

ART. X. Fishing of all kinds, by whatever means and at all seasons, may be carried on in the seas lying beyond the fishery limits which have been fixed for the two countries, with the exception of that for oysters, as hereinafter expressed.

ART. XI. From the 16th of June to the 31st of August, inclusive, fishing for oysters is prohibited outside the fishery limits which have been fixed for the two countries, between a line drawn from the North Foreland Light to Dunkirk, and a line drawn from the Land's End to Ushant.

During the same period and in the same part of the channel, no boat shall have on board any oyster dredge, unless the same be tied up and sealed by the Customs authorities of one of the two countries in such a manner as to prevent its being made use of.

ART. XII. No boat shall anchor between sunset and sunrise on grounds where drift-net fishing is actually going on.

This prohibition shall not apply to anchorings which may take place in consequence of accidents, or any other compulsory circumstances; but in such case the master of the boat thus obliged to anchor shall hoist, so that they shall be seen from a distance, two lights placed horizontally about three feet (1 mètre French) apart, and shall keep those lights up all the time the boat shall remain at anchor.

ART. XIII. Boats fishing with drift nets shall carry on one of their masts two lights, one over the other, three feet (1 mètre French) apart.

These lights shall be kept up during all the time their nets shall be in the sea between sunset and sunrise.

ART. XIV. Subject to the exceptions or additions mentioned in the two preceding Articles, the fishing boats of the two countries shall conform to the general rules respecting lights which have been adopted by the two countries.

ART. XV. Trawl boats shall not commence fishing at a less distance than three miles from any boat fishing with drift nets.

If trawl boats have already shot their nets, they must not come nearer to boats fishing with drift nets than the distance above mentioned.

ART. XVI. No boat fishing with drift nets shall shoot its nets so near to any other boat which has already shot its nets on the fishing ground as to interfere with its operations.

ART. XVII. No decked boat fishing with drift nets shall shoot its nets at a less distance than a quarter of a mile from any undecked boat which is already engaged in fishing.

ART. XVIII. If the spot where fishing is going on should be so near to the fishery limits of one of the two countries that the boats of the other country would, by observing the regulations prescribed by Articles XV, XVI, and XVII preceding, be prevented from taking part in the fishery, such boats shall be at liberty to shoot their nets at a less distance than that so described; but in such case the fishermen shall be responsible for any damage or losses which may be caused by the drifting of their boats.

ART. XIX. Nets shall not be set or anchored in any place where drift-net fishing is actually going on.

ART. XX. No one shall make fast or hold on his boat to the nets, buoys, floats, or any part of the fishing tackle belonging to another boat.

No person shall hook or lift up the nets, lines, or other fishing implements belonging to another person.

ART. XXI. When nets of different boats get foul of each other, the master of one boat shall not cut the nets of another boat except by mutual consent, and unless it be found impossible to clear them by other means.

ART. XXII. All fishing boats, all rigging gear or other appurtenances of fishing boats, all nets, buoys, floats, or other fishing implements whatsoever, found or picked up at sea, shall, as soon as possible, be delivered to the Receiver of Wreck if the article saved be taken into the United Kingdom, and to the Commissary of Marine if the article saved be taken into France.

The Receiver of Wreck or the Commissary of Marine, as the case may be, shall restore the articles saved to the owners thereof, or to their representatives.

These functionaries shall fix the amount which the owners shall pay to the salvors.

ART. XXIII. The execution of the regulations concerning lights and signals, licences, muster rolls, and official papers, the lettering and numbering of boats and implements of fishing, is placed, with respect to the fishermen of each of the two nations, under the exclusive superintendence of the cruizers and agents of their own nation.

Nevertheless, the commanders of the cruizers of one of the two nations shall acquaint the commanders of the cruizers of the other nation with any infractions of the above-mentioned regulations committed by the fishermen of such other nation which may come to their knowledge.

ART. XXIV. All infractions of the regulations concerning the placing of boats on the fishing ground, the distances to be observed between them, the prohibition of oyster fishing during a portion of the year, and concerning every other operation connected with the act of fishing, and more particularly concerning circumstances likely to cause damage, shall be taken cognizance of by the cruizers of either nation, whichever may be the nation to which the fishermen guilty of such infractions may belong.

ART. XXV. The commanders of cruizers of either country shall exercise their judgment as to the causes of any infractions brought to their knowledge, or as to damage arising from any cause whatever committed by British or French fishing boats in the seas beyond the fishery limits which have been fixed for the two countries; they may detain the offending boats and take them into the port nearest the scene of the occurrence, in order that the infraction or damage may be there duly established, as well by comparing the declarations and counter declarations of the parties interested as by the testimony of those who were present.

ART. XXVI. When the offense shall not be such as to require exemplary punishment, but shall nevertheless have caused damage to any fisherman, the commanders of the cruizers shall be at liberty, should the circumstances admit of it, to arbitrate at sea between the parties concerned. On refusal of the offenders to defer to their arbitration, the said commanders shall take both them and their boats into the nearest port, to be dealt with as stated in the preceding Article.

ART. XXVII. Every fishing boat which shall have been taken into a foreign port in conformity with the two preceding Articles shall be sent back to her own country for trial as soon as the infraction for which she may have been detained shall have been duly established. Neither the boat nor her crew shall, however, be detained in the foreign port more than three clear days.

ART. XXVIII. The depositions, minutes of proceedings, and all other documents concerning the infraction, after having been authenticated by the Collector of Customs in the United Kingdom, or by the Commissary of Marine in France, shall be transmitted by that functionary to the consular agent of his nation residing in the port where the trial is to take place.

Such Consular Agent shall communicate those documents to the Collector of Customs, or to the Commissary of Marine, as the case may be; and if, after having conferred with that functionary, it shall be necessary for the interest of his countrymen, he shall proceed with the affair before the competent tribunal or magistrates of the country.

ART. XXIX. In both countries the competent court or magistrate shall be empowered to condemn to a fine of at least eight shillings (ten francs), or to imprisonment for at least two days, persons who may infringe the regulations of the convention concerning—

1. The close season for oysters, and illegal possession of dredges on board during that season.
2. The letters, numbers, and names to be placed on the boats, sails, nets, and buoys.
3. The licenses or muster rolls.
4. The flags and lights to be carried by the boats.
5. The distances to be observed by the boats between each other.
6. The placing and anchoring of vessels and boats.
7. The placing and shooting of nets and the taking them up.
8. The clearing of nets.
9. The placing of buoys upon nets.

In case of repetition of the offence the amount of fine or period of imprisonment may be doubled.

ART. XXX. In all cases of assault committed or of damage or loss inflicted at sea by fishermen of either country upon fishermen of the other country, the Courts of the country to which the offenders belong shall condemn the latter to a fine of at least eight shillings (10 francs), or to imprisonment for at least two days. They may, moreover, condemn the offenders to pay adequate compensation for the injury.

ART. XXXI. Fishing boats of either of the two countries shall be admitted to sell their fish in such ports of the other country as may be designated for that purpose, on condition that they conform to the regulations mutually agreed upon. Those regulations, together with a list of the ports, are annexed to the present Convention, but without prejudice to the opening by either country of any additional ports.

ART. XXXII. The fishing boats of the one country shall not enter within the fishery limits fixed for the other country except under the following circumstances:

1. When driven by stress of weather or by evident damage.

2. When carried in by contrary winds, by strong tides, or by any other cause beyond the control of the master and crew.

3. When obliged by contrary winds or tide to beat up in order to reach their fishing ground; and when from the same cause of contrary wind or tide they could not, if they remained outside, be able to hold on their course to their fishing ground.

4. When, during the herring fishing season, the herring boats of the one country shall find it necessary to anchor under shelter of the coasts of the other country in order to await the opportunity for proceeding to their fishing ground.

5. When proceeding to any of the ports of the other country open to them for the sale of fish in accordance with the preceding article; but in such case they shall never have oyster dredges on board.

ART. XXXIII. When fishing boats, availing themselves of the privilege specified in Article XXXI, shall have oysters on board they shall not carry any dredges or other implement for taking oysters.

ART. XXIV. The commanders of cruizers may authorise boats belonging to their own country to cross the exclusive fishery limits of the other country whenever the weather is so threatening as to compel them to seek shelter.

ART. XXXV. Whenever, owing to any of the exceptional circumstances specified in the three preceding Articles, the fishing boats of either country shall be in the ports or within the fishery limits fixed for the other country, the masters of such boats shall immediately hoist a blue flag two feet (60 centimètres French) high, and three feet (1 mètre French) long, and shall keep that flag flying at the masthead so long as they remain in such ports or within such limits. The flag shall be hauled down as soon as the boat is outside the said limits.

Such boats must return outside the said limits as soon as the exceptional circumstances which obliged them to enter shall have ceased.

ART. XXXVI. The commanders of the cruizers of each of the two countries, and all officers or other agents appointed to superintend fisheries, shall exercise their judgment as to infractions of the regulations with regard to the fishery limits, and when they shall be satisfied of the fact of the infraction they may detain the boats of the offenders, or cause them to be detained, and may take them, or cause them to be taken, into port, where, upon clear proof of the offence, such boats may be condemned by the competent Court or magistrate to a fine not exceeding ten pounds (250 francs). In default of payment, such boats may be detained for a period not exceeding three months

In case of repetition of the offence the fine may be doubled.

ART. XXXVII. The proceedings and trial in cases of infraction of the provisions of the present Convention shall take place as speedily and as summarily as the laws in force will permit.

ART. XXXVIII. The terms "British Islands" and "United Kingdom," employed in this Convention, shall include the islands of Jersey, Guernsey, Alderney, Sark, and Man, with their dependencies.

ART. XXXIX. Her Britannic Majesty engages to recommend to Parliament to pass an Act to enable her to carry into execution such of the arrangements contained in the present Convention as require legislative sanction. When such an Act shall have been passed, the Convention shall come into operation from and after a day to be then fixed upon by the two High Contracting Parties. Due notice shall be given in each country by the Government of that country of the day which may be so fixed upon.

ART. XL. The Convention shall continue in force for ten years from the day on which it may come into operation, and if neither party shall, twelve months before the expiration of the said period of ten years, give notice of its intention to terminate its operation, the Convention shall continue in force one year longer, and so on from year to year, until the expiration of one year's notice from either party for its termination.

The High Contracting Parties, however, reserve to themselves the power to make, by mutual consent, any modification in the convention which experience shall have shown to be desirable, provided it is not inconsistent with the principles on which it is based.

ART. XLI. The Convention concluded between the High Contracting Parties on the 2d of August, 1839, and the Regulations of the 23d of June, 1843, shall continue in force until the day when, as provided in Article XXXIX, the present Convention shall come into operation, and shall then altogether cease and determine.

ART. XLII. The present Convention shall be ratified, and the ratifications shall be exchanged as soon as possible.

In witness whereof the respective Plenipotentiaries have signed the same, and have affixed thereto the seals of their arms.

Done at Paris, the 11th of November, in the year of our Lord 1867.

ADDITIONAL ARTICLE. It is agreed that Article XXXI of the convention signed this day shall not come into operation until the two Contracting Parties shall have come to a further understanding on the subject. Due notice shall be given of the day that may be fixed upon for its coming into operation.

The present Additional Article shall have the same force and validity as if it were inserted, word for word, in the Convention signed this day. It shall be ratified and the ratifications shall be exchanged at the same time as those of the convention.

In witness whereof the respective Plenipotentiaries have signed the same, and have affixed thereto the seals of their arms.

Done at Paris, the 11th of November, in the year of our Lord 1867.

APPENDIX C.

International Convention (of 1882 between Belgium, Denmark, France, Germany, Great Britain, and the Netherlands) for the purpose of regulating the Police of the fisheries in the North Sea outside Territorial Waters.

ARTICLE I. The provisions of the present Convention, the object of which is to regulate the police of the fisheries in the North Sea outside territorial waters, shall apply to the subjects of the High Contracting Parties.

ART. II. The fishermen of each country shall enjoy the exclusive right of fishery within the distance of three miles from low-water mark along the whole extent of the coasts of their respective countries, as well as of the dependent islands and banks.

As regards bays, the distance of three miles shall be measured from a straight line drawn across the bay, in the part nearest the entrance, at the first point where the width does not exceed ten miles.

The present Article shall not in any way prejudice the freedom of navigation and anchorage in territorial waters accorded to fishing boats, provided they conform to the special police regulations enacted by the Powers to whom the shore belongs.

ART. III. The miles mentioned in the preceding Article are geographical miles, whereof sixty make a degree of latitude.

ART. IV. For the purpose of applying the provisions of the present Convention, the limits of the North Sea shall be fixed as follows:

1. On the north by the parallel of the 61st degree of latitude.
2. On the east and south:

(1) By the coasts of Norway between the parallel of the 61st degree of latitude and Lindesnaes Light-house (Norway).

(2) By a straight line drawn from Lindesnaes Light-house (Norway) to Hanstholm Light-house (Denmark).

(3) By the coasts of Denmark, Germany, the Netherlands, Belgium, and France, as far as Gris Nez Light-house.

3. On the west:

(1) By a straight line drawn from Gris Nez Light-house (France) to the easternmost light-house at South Foreland (England).

(2) By the eastern coasts of England and Scotland.

(3) By a straight line joining Duncansby Head (Scotland) and the southern point of South Ronaldsha (Orkney Islands).

(4) By the eastern coasts of the Orkney Islands.

(5) By a straight line joining North Ronaldsha Light-house (Orkney Islands) and Sumburgh Head Light-house (Shetland Islands).

(6) By the eastern coasts of the Shetland Islands.

(7) By the meridian of North Unst Light-house (Shetland Islands) as far as the parallel of the 61st degree of latitude.

ART. V. The fishing boats of the high contracting parties shall be registered in accordance with the administrative regulations of each country. For each port there shall be a consecutive series of numbers, preceded by one or more initial letters, which shall be specified by the superior competent authority.

Each Government shall draw up a list showing these initial letters.

This list, together with all modifications which may subsequently be made in it, shall be notified to the other contracting powers.

ART. VI. Fishing boats shall bear the initial letter or letters of the port to which they belong, and the registry number in the series of numbers for that port.

ART. VII. The name of each fishing boat, and that of the port to which she belongs, shall be painted in white oil colour on a black ground on the stern of the boat, in letters which shall be at least eight centimètres in height and twelve millimètres in breadth.

ART. VIII. The letter or letters and numbers shall be placed on each bow of the boat, eight or ten centimètres below the gunwale, and so as to be clearly visible. They shall be painted in white oil colour on a black ground.

The distance above mentioned shall not, however, be obligatory for boats of small burden, which may not have sufficient space below the gunwale.

For boats of fifteen tons burden and upward the dimensions of the letters and numbers shall be forty-five centimètres in height and six centimètres in breadth.

For boats of less than fifteen tons burden the dimensions shall be twenty-five centimètres in height and four centimètres in breadth.

The same letter or letters and numbers shall also be painted on each side of the mainsail of the boat, immediately above the close reef, in black oil color on white or tanned sails, and in white oil color on black sails.

The letter or letters and numbers on the sails shall be one-third larger in every way than those placed on the bows of the boat.

ART. IX. Fishing boats may not have, either on their outside or on their sails, any names, letters, or numbers other than those prescribed by Articles VI, VII, and VIII of the present convention.

ART. X. The names, letters, and numbers placed on the boats and on their sails shall not be effaced, altered, made illegible, covered, or concealed in any manner whatsoever.

ART. XI. All the small boats, buoys, principal floats, trawls, grapnels, anchors, and generally all fishing implements, shall be marked with the letter or letters and numbers of the boats to which they belong.

These letters and numbers shall be large enough to be easily distinguished. The owners of the nets or other fishing implements may further distinguish them by any private marks they think proper.

ART. XII. The master of each boat must have with him an official document, issued by the proper authority in his own country, for the purpose of enabling him to establish the nationality of his boat.

This document must always give the letter or letters and number of the boat, as well as her description and the name or names of the owner or the name of the firm or association to which she belongs.

ART. XIII. The nationality of a boat must not be concealed in any manner whatsoever.

ART. XIV. No fishing boat shall anchor, between sunset and sunrise, on grounds where drift-net fishing is actually going on.

This prohibition shall not, however, apply to anchorings which may take place in consequence of accidents or of any other compulsory circumstances.

ART. XV. Boats arriving on the fishing grounds shall not either place themselves or shoot their nets in such a way as to injure each other, or as to interfere with fishermen who have already commenced their operations.

ART. XVI. Whenever, with a view of drift-net fishing, decked boats and undecked boats commence shooting their nets at the same time, the undecked boats shall shoot their nets to windward of the decked boats.

The decked boats, on their part, shall shoot their nets to leeward of the undecked boats.

As a rule, if decked boats shoot their nets to windward of undecked boats which have begun fishing, or if undecked boats shoot their nets to leeward of decked boats which have begun fishing, the responsibility as regards any damages to nets which may result shall rest with the boats which last began fishing, unless they can prove that they were under stress of compulsory circumstances, or that the damage was not caused by their fault.

ART. XVII. No net or any other fishing engine shall be set or anchored on grounds where drift-net fishing is actually going on.

ART. XVIII. No fisherman shall make fast or hold on his boat to the nets, buoys, floats, or any other part of the fishing tackle of another fisherman.

ART. XIX. When trawl fishermen are in sight of drift-net or of long-line fishermen, they shall take all necessary steps in order to avoid doing injury to the latter. Where damage is caused, the responsibility shall lie on the trawlers, unless they can prove that they were under stress of compulsory circumstances, or that the loss sustained did not result from their fault.

ART. XX. When nets belonging to different fishermen get foul of each other, they shall not be cut without the consent of both parties.

All responsibility shall cease if the impossibility of disengaging the nets by any other means is proved.

ART. XXI. When a boat fishing with long lines entangles her lines in those of another boat, the person who hauls up the lines shall not cut them except under stress of compulsory circumstances, in which case any line which may be cut shall be immediately joined together again.

ART. XXII. Except in cases of salvage and the cases to which the two preceding articles relate, no fisherman shall, under any pretext whatever, cut, hook, or lift up nets, lines, or other gear not belonging to him.

ART. XXIII. The use of any instrument or engine which serves only to cut or destroy nets is forbidden.

The presence of any such engine on board a boat is also forbidden.

The high contracting parties engage to take the necessary measures for preventing the embarkation of such engines on board fishing boats.

ART. XXIV. Fishing boats shall conform to the general rules respecting lights which have been, or may be, adopted by mutual arrangement between the high contracting parties with the view of preventing collisions at sea.

ART. XXV. All fishing boats, all their small boats, all rigging gear or other appurtenances of fishing boats, all nets, lines, buoys, floats, or other fishing implements whatsoever found or picked up at sea, whether marked or unmarked, shall as soon as possible be delivered to the competent authority of the first port to which the salving boat returns or puts in.

Such authority shall inform the consul or consular agent of the country to which the boat of the salvor belongs, and of the nation of the owner of the articles found. They [the same authority] shall restore the articles to the owners thereof or to their representatives, as soon as such articles are claimed and the interests of the salvors have been properly guaranteed.

The administrative or judicial authorities, according as the laws of the different countries may provide, shall fix the amount which the owners shall pay to the salvors.

It is, however, agreed that this provision shall not in any way prejudice such conventions respecting this matter as are already in force, and that the high contracting parties reserve the right of regulating, by special arrangements between themselves, the amount of salvage at a fixed rate per net salved.

Fishing implements of any kind found unmarked shall be treated as wreck.

ART. XXVI. The superintendence of the fisheries shall be exercised by vessels belonging to the national navies of the high contracting parties. In the case of Belgium, such vessels may be vessels belonging to the State, commanded by captains who hold commissions.

ART. XXVII. The execution of the regulations respecting the document establishing nationality, the marking and numbering of boats, etc., and of fishing implements, as well as the presence on board of instruments which are forbidden (Articles VI, VII, VIII, IX, X, XI, XII, XIII, and XXIII, sec. 2), is placed under the exclusive superintendence of the cruisers of the nation of each fishing boat.

Nevertheless, the commanders of cruisers shall acquaint each other with any infractions of the above-mentioned regulations committed by the fishermen of another nation.

ART. XXVIII. The cruisers of all the high contracting parties shall be competent to authenticate all infractions of the regulations prescribed by the present Convention, other than those referred to in Article XXVII, and all offences relating to fishing operations, whichever may be the nation to which the fisherman guilty of such infractions may belong.

ART. XXIX. When the commanders of cruisers have reason to believe that an infraction of the provisions of the present convention has been committed, they may require the master of the boat inculpated to exhibit the official document establishing her nationality. The fact of such document having been exhibited shall then be indorsed upon it immediately.

The commanders of cruisers shall not pursue further their visit or search on board a fishing boat which is not of their own nationality, unless it should be necessary for the purpose of obtaining proof of an offence or of a contravention of regulations respecting the police of the fisheries.

ART. XXX. The commanders of the cruisers of the signatory powers shall exercise their judgment as to the gravity of facts brought to their knowledge, and of which they are empowered to take cognizance, and shall verify the damage, from whatever cause arising, which may be sustained by fishing boats of the nationalities of the high contracting parties.

They shall draw up, if there is occasion for it, a formal statement of the verification of the facts as elicited both from the declarations of the parties interested and from the testimony of those present.

The commander of the cruiser may, if the case appears to him sufficiently serious to justify the step, take the offending boat into a port of the nation to which the fisherman belongs. He may even take on board the cruiser a part of the crew of the fishing boat in order to hand them over to the authorities of her nation.

ART. XXXI. The formal statement referred to in the preceding Article shall be drawn up in the language of the commander of the cruiser, and according to the forms in use in his country.

The accused and the witnesses shall be entitled to add, or to have added, to such statement, in their own language, any observations or evidence which they may think suitable. Such declarations must be duly signed.

ART. XXXII. Resistance to the directions of commanders of cruisers charged with the police of the fisheries, or of those who act under their orders, shall, without taking into account the nationality of the cruiser, be considered as resistance to the authority of the nation of the fishing boat.

ART. XXXIII. When the act alleged is not of a serious character, but has nevertheless caused damage to any fisherman, the commanders of cruisers shall be at liberty, should the parties concerned agree to it, to arbitrate at sea between them, and to fix the compensation to be paid.

Where one of the parties is not in a position to settle the matter at once, the commanders shall cause the parties concerned to sign in duplicate a formal document specifying the compensation to be paid.

One copy of this document shall remain on board the cruiser and the other shall be handed to the master of the boat to which the compensation is due, in order that he may, if necessary, be able to make use of it before the courts of the country to which the debtor belongs.

Where, on the contrary, the parties do not consent to arbitration, the commanders shall act in accordance with the provisions of Article XXX.

ART. XXXIV. The prosecutions for offences against, or contraventions of, the present convention shall be instituted by, or in the name of, the State.

ART. XXXV. The high contracting parties engage to propose to their respective Legislatures the necessary measures for ensuring the execution of the present Convention, and particularly for the punishment by either fine or imprisonment, or by both, of persons who may contravene the provsions of Articles VI to XXIII inclusive.

ART. XXXVI. In all cases of assault committed, or of willful damage or loss inflicted, by fishermen of one of the contracting countries upon fishermen of another nationality, the courts of the country to which the boats of the offenders belong shall be empowered to try them.

The same rule shall apply with regard to offences against, and contraventions of, the present Convention.

ART. XXXVII. The proceedings and trial in cases of infraction of the provisions of the present convention shall take place as summarily as the laws and regulations in force will permit.

ART. XXXVIII. The present Convention shall be ratified. The ratifications shall be exchanged at The Hague as soon as possible.

ART. XXXIX. The present Convention shall be brought into force from and after a day to be agreed upon by the high contracting parties.

The Convention shall continue in operation for five years from the above day; and unless one of the high contracting parties shall, twelve months before the expiration of the said period of five years, give notice of intention to terminate its operation, shall continue in force one year longer, and so on from year to year. If, however, one of the Signatory Powers should give notice to terminate the convention, the same shall be maintained between the other contracting parties, unless they give a similar notice.

ADDITIONAL ARTICLE. The Government of His Majesty the King of Sweden and Norway may adhere to the present Convention, for Sweden and for Norway, either jointly or separately.

This adhesion shall be notified to the Netherlands Government, and by it to the other Signatory Powers.

In witness whereof the Plenipotentiaries have signed the present convention and have affixed thereto their seals.

Done at The Hague, in six copies, the 6th of May, 1882.

APPENDIX D.

Anglo-Belgian Declaration respecting the North Sea Fisheries.

ARTICLE I. Whenever a complaint involving a claim for damages shall be preferred by a fisherman of one of the two countries against a fisherman of the other country, it shall be referred for preliminary inquiry—in Belgium, to a Commission composed of at least two officers appointed by the Minister of Railways, Posts, and Telegraphs; in the United Kingdom, to a Commission also composed of at least two officers appointed by the Board of Trade; these officers shall hold their inquiry at the place where the allegations of the complainants can most easily be verified.

ART. II. No complaint shall be transmitted either to the British or to the Belgian Government, as the case may be, unless:

1. The commission has recognised it as well founded.
2. Such fishermen as are specified by the commission engage themselves to appear in person in case they should be summoned to give evidence.

ART. III. The complaints must be accompanied by—

1. A Report from the Commission of Inquiry.
2. A certificate from this Commission, verifying the ownership of the lost or injured fishing gear.
3. A certificate of an expert nominated (as the case may be), in the United Kingdom by the Board of Trade, in Belgium by the Minister of Railways, Posts, and Telegraphs, and giving an estimate of the damages in money value.

These certificates must be forwarded through the proper diplomatic channel, and shall be received as evidence unless the contrary is proved.

ART. IV. When a fisherman fouls or otherwise interferes with the fishing gear of another fisherman he shall take all necessary measures for reducing to a minimum the injuries which may result to the gear or to the boat of the other fisherman.

ART. V. In the Kingdom of Belgium the Tribunal which has cognizance of an infraction of the North Sea Fisheries Convention of the 6th May, 1882, or of Article 4 of the present Declaration, shall be empowered to award damages for injury to person or property at the request of the injured party and at the suit of the Official Prosecutor.

The execution of awards of damages shall be effected, on the application of the Official Prosecutor by the competent Administration, which will advance the costs and recover them from the condemned parties according to the usual process of law in such cases.

In the United Kingdom the Court before which proceedings are taken for the above-mentioned infractions shall be empowered, at the suit of the Official Prosecutor on the request of the injured party, to award damages for injury to person or property, and the Official Prosecutor shall, at his own cost, recover the sum so awarded, or so much thereof as is possible, from the parties liable.

The amount of damages recovered, as stipulated above, shall be remitted free of cost to the injured party through the proper diplomatic channel.

ART. VI. The High Contracting Parties engage to take, or to propose to their respective legislatures, the necessary measures for insuring the execution of the present Declaration, and especially for punishing, either by fine or imprisonment, or both, persons who may contravene Article IV.

ART. VII. The present Declaration shall be ratified, and the ratifications shall be exchanged at Brussels as soon as possible.

ART. VIII. The present Declaration shall come into force at a date to be agreed upon subsequently by the High Contracting Parties.

It shall remain in force for three years from that date, and in the event of neither of the High Contracting Parties having notified twelve months before the expiry of the said period of three years their intention of terminating it, it shall continue to remain in force for a year, and so on from year to year.

In witness whereof the undersigned Envoy Extraordinary and Minister Plenipotentiary at Brussels of Her Majesty the Queen of the United Kingdom of Great Britain and Ireland, and the undersigned Minister for Foreign Affairs of His Majesty the King of the Belgians, have drawn up the present Declaration in duplicate, and have affixed thereto the seals of their arms.

Done at Brussels, the 2d May, 1891.

APPENDIX E.

Fishery Articles of the Submarine Cable Convention of 1884.

ARTICLE I. The present Convention shall be applicable, outside of the territorial waters, to all legally established submarine cables landed in the territories, colonies, or possessions of one or more of the High Contracting Parties.

ART. II. The breaking or injury of a submarine cable, done willfully or through culpable negligence, and resulting in the total or partial interruption or embarrassment of telegraphic communication, shall be a punishable offense, but the punishment inflicted shall be no bar to a civil action for damages. This provision shall not apply to ruptures or injuries when the parties guilty thereof have become so simply with the legitimate object of saving their lives or their vessels, after having taken all necessary precautions to avoid such ruptures or injuries.

ART. V. Vessels engaged in laying or repairing submarine cables must observe the rules concerning signals that have been or shall be adopted, by common consent, by the High Contracting Parties, with a view to preventing collisions at sea. When a vessel engaged in repairing a cable carries the said signals, other vessels that see or are able to see those signals shall withdraw or keep at a distance of at least one nautical mile from such vessel, in order not to interfere with its operations. Fishing gear and nets shall be kept at the same distance. Nevertheless, a period of twenty-four hours at most shall be allowed to fishing vessels that perceive or are able to perceive a telegraph ship carrying the said signals, in order that they may be enabled to obey the notice thus given, and no obstacle shall be placed in the way of their operations during such period. The operations of telegraph ships shall be finished as speedily as possible.

ART. VI. Vessels that see or are able to see buoys designed to show the position of cables when the latter are being laid, are out of order, or are broken, shall keep at the distance of one-quarter of a nautical mile at least from such buoys. Fishing nets and gear shall be kept at the same distance.

ART. VII. Owners of ships or vessels who can prove that they have sacrificed an anchor, a net, or any other implement used in fishing, in order to avoid injuring a submarine cable, shall be indemnified by the owner of the cable In order to be entitled to such indemnity, one must prepare, whenever possible, immediately after the accident, in proof thereof, a statement supported by the testimony of the men belonging to the crew, and the captain of the vessel must, within twenty-four hours after at the first port of temporary entry, make his declaration to the competent authorities. The latter shall give notice thereof to the consular authorities of the nation to which the owner of the cable belongs.

APPENDIX F.

Convention between the United Kingdom and Denmark for regulating the Fisheries outside Territorial Waters in the Ocean surrounding the Faröe Islands and Iceland.

ARTICLE I. The provisions of the present Convention, the object of which is to regulate the police of the fisheries in the ocean surrounding the Faröe Islands and Iceland outside the territorial waters of these islands, shall apply to the subjects of the High Contracting Parties.

ART. II. The subjects of His Majesty the King of Denmark shall enjoy the exclusive right of fishery within the distance of three miles from low-water mark along the whole extent of the coasts of the said islands, as well as of the dependent islets, rocks, and banks.

As regards bays, the distance of three miles shall be measured from a straight line drawn across the bay, in the part nearest the entrance, at the first point where the width does not exceed ten miles.

The present article shall not prejudice the freedom of navigation or anchorage in territorial waters accorded to fishing boats, provided they conform to the Danish Police Regulations ruling this matter, amongst others the one stipulating that trawling vessels, while sojourning in territorial waters, shall have their trawling gear stowed away inboard.

ART. III. The miles mentioned in the preceding Article are geographical miles, whereof sixty make a degree of latitude.

ART. IV. The geographical limits for the application of the present Convention shall be fixed as follows:

On the south by a line commencing from where the meridian of North Unst Light-house (Shetland Islands) meets the parallel of 61st degree of north latitude to a point where the 9th meridian of west longitude meets the parallel of 60° north latitude, and from thence westward along that parallel to the meridian of 27° west longitude.

On the west by the meridian of 27° west longitude.

On the north by the parallel of 67° 30′ of north latitude.

On the east by the meridian of the North Unst Light-house.

The aforesaid limits are shown on the chart appended to the present Convention.

ART. V. The fishing boats of the High Contracting Parties shall be registered in accordance with the administrative Regulations in force in their respective countries.

For each port there shall be a consecutive series of numbers, preceded by one or two initial letters, which shall be specified by the superior competent authority.

Each Government shall draw up a list showing these initial letters.

This list, together with all modifications which may subsequently be made in it, shall be notified to the other Government.

ART. VI. Fishing boats shall bear the initial letter or letters of the port to which they belong, and the registry number in the series of numbers for that port.

ART. VII. The name of each fishing boat and that of the port to which she belongs shall be painted in white oil colour on a black ground on the stern of the boat in letters which shall be at least eight centimètres in height and twelve millimètres in breadth.

ART. VIII. The letter or letters and numbers which shall have been assigned to a vessel on its registration shall be painted in white oil colour on a black ground, and so as to be clearly visible on each bow of the vessel, eight or ten centimètres below the gunwale, provided the space admit it. The letters and numbers of vessels of fifteen tons burden (gross tonnage) and upwards shall be forty-five centimètres in height and six centimètres in breadth.

For boats of less than fifteen tons burden (gross tonnage) the dimensions shall, if possible, be twenty-five centimètres in height and four centimètres in breadth.

The same letters and numbers shall also be painted in oil colour on each side of the mainsail of the boat immediately above the close reef, and in such a manner as to be plainly visible; they shall be painted on white sails in black, or black sails in white, and on sails of an intermediate shade in black or in white, as may be decided by the authority superintending the marking, in accordance with Article V of the present Convention.

Steam fishing vessels shall, in addition, bear the above marks on the funnel in a plainly visible manner. These marks should be of the same dimensions as those on the bow.

The letter or letters and numbers on the sails shall be one-third larger in every way than those placed on the bows of the boat.

ART. IX. Fishing boats may not have, either on their outside, on their sails, or on their funnels, any names, letters, or numbers other than those prescribed by Articles VI, VII, and VIII of the present Convention.

ART. X. The names, letters, and numbers placed on the boats and on their sails and funnels shall not be effaced, altered, made illegible, covered or concealed in any manner whatsoever.

ART. XI. All the small boats, buoys, principal floats, trawls, grapnels, anchors, and generally all fishing implements shall be marked with the letter or letters and numbers of the boats to which they belong.

These letters and numbers shall be large enough to be easily distinguished. The owners of the nets or other fishing implements may further distinguish them by any private marks they think proper.

ART. XII. The master of each boat must have with him an official document, issued by the proper authority in his own country, for the purpose of enabling him to establish the nationality of the boat

This document must always give the letter or letters and number of the boat, as well as her description and the name or names of the owner or the name of the firm or association to which she belongs.

ART. XIII. The nationality of a boat must not be concealed in any manner whatsoever.

ART. XIV. No fishing boat shall anchor, between sunset and sunrise, on grounds where drift-net fishing is actually going on.

This prohibition shall not, however, apply to anchorings which may take place in consequence of accidents or of any other compulsory circumstances.

ART. XV. Boats arriving on the fishing grounds shall not either place themselves or shoot their nets in such a way as to injure each other, or as to interfere with fishermen who have already commenced their operations.

ART. XVI. Whenever, with a view of drift-net fishing, decked boats and undecked boats commence shooting their nets at the same time, the undecked boats shall shoot their nets to windward of the decked boats.

The decked boats, on their part, shall shoot their nets to leeward of the undecked boats.

As a rule, if decked boats shoot their nets to windward of undecked boats which have begun fishing, or if undecked boats shoot their nets to leeward of decked boats which have begun fishing, the responsibility as regards any damages to nets which may result shall rest with the boats which last began fishing, unless they can prove that they were under stress of compulsory circumstances or that the damage was not caused by their fault.

ART. XVII. No net or any other fishing engine shall be set or anchored on grounds where drift-net fishing is actually going on.

ART. XVIII. No fisherman shall make fast or hold on his boat to the nets, buoys, floats, or any other parts of the fishing tackle of another fisherman.

ART. XIX. When trawl fishermen are in sight of net or of long-line fishermen, they shall take all necessary steps in order to avoid doing injury to the latter. Where damage is caused the responsibility shall be on the trawlers, unless they can prove that they were under stress of compulsory circumstances, or that the loss sustained did not result from their fault.

ART. XX. When nets belonging to different fishermen get foul of each other, they shall not be cut without the consent of both parties.

All responsibility shall cease if the impossibility of disengaging the nets by any other means is proved.

ART. XXI. When a boat fishing with long lines entangles her lines in those of another boat, the person who hauls up the lines shall not cut them, except under stress of compulsory circumstances, in which case any line which may be cut shall be immediately joined together again.

ART. XXII. Except in case of salvage and the cases to which the two preceding Articles relate, no fisherman shall, under any pretext whatever, cut, hook, or lift up nets, lines, or other gear not belonging to him.

When a fisherman fouls or otherwise interferes with the fishing gear of another fisherman, he shall take all necessary measures for reducing to a minimum the injuries which may result to the gear or to the boat of the other fisherman.

ART. XXIII. The use of any instrument or engine which serves only to cut or destroy nets is forbidden.

The presence of any such engine on board a boat is also forbidden.

The High Contracting Parties engage to take the necessary measures for preventing the embarkation of such engines on board fishing boats.

ART. XXIV. Fishing boats shall conform to the general rules respecting lights and sound signals, as well as those concerning steering and navigation, which have been, or may be, adopted in respect of these boats by mutual arrangement between the High Contracting Parties with the view of preventing collisions at sea.

ART. XXV. All fishing boats, all their small boats, all rigging gear, or other appurtenances of fishing boats, all nets, buoys, floats, or other fishing implements whatsoever found or picked up at sea, whether marked or unmarked, shall as soon as possible be delivered to the competent authority of the first port to which the salving boat returns or puts in.

Such authority shall inform the Consul or Consular Agent of the country to which the boat of the salvor belongs, and the nation of the owners of the articles found. They (the same authority) shall restore the articles to the owners thereof, or to their representatives, as soon as such articles are claimed and the interests of the salvors have been properly guaranteed.

The administrative or judicial authorities, according as the laws of the respective countries may provide, shall fix the amount which the owner shall pay to the salvors. It is, however, agreed that this provision shall not in any way prejudice such Conventions respecting this matter as are already in force, and that the High Contracting Parties reserve the right of regulating, by special arrangements between themselves, the amount of salvage at a fixed rate per net salved.

Fishing implements of any kind found unmarked shall be treated as wreck.

ART. XXVI. The superintendence of the fisheries shall be exercised by vessels belonging to the national navies of the High Contracting Parties. In the case of Denmark such vessels may be vessels belonging to the state, commanded by Captains who hold commissions.

ART. XXVII. The execution of the Regulations respecting the documents establishing nationality, the marking and numbering of boats, etc., and of fishing implements, as well as the presence on board of instruments which are forbidden (Articles VI, VII, VIII, IX, X, XI, XII, XIII, and XXIII, paragraph 2), is placed under the exclusive superintendence of the cruisers of the nation of each fishing boat. Nevertheless, the Commanders of cruizers shall acquaint each other with any infractions of the above-mentioned Regulations committed by the fishermen of the other nation.

ART. XXVIII. The cruizers of the High Contracting Parties shall be competent to authenticate all infractions of the Regulations prescribed by the present Convention other than those referred to in Article XXVII, and all offences relating to fishing operations, whichever may be the nation to which the fishermen guilty of such infraction may belong.

ART. XXIX. When the Commanders of cruizers have reason to believe that an infraction of the provisions of the present Convention has been committed, they may require the master of the boat inculpated to exhibit the official document establishing her nationality. The fact of such document having been exhibited shall then be indorsed upon it immediately. The Commanders of cruizers shall not pursue further their visit or search on board a fishing boat which is not of their own nationality, unless it should be for the purpose of obtaining proof of an offence or of a contravention of Regulations respecting the police of the fisheries.

ART. XXX. The Commanders of the cruizers of the High Contracting Parties shall exercise their judgment as to the gravity of facts brought to their knowledge, and of which they are empowered to take cognizance, and shall verify the damage, from whatever cause arising, which may be sustained by fishing boats of the nationalities of the High Contracting Parties.

They shall draw up, if there is occasion for it, a formal statement of the verification of the facts, as elicited both from the declaration of the parties interested and from the testimony of those present

The Commander of the cruizer may, if the case appears to him sufficiently serious to justify the step, take the offending boat into a port of the nation to which the fisherman belongs.

He may even take on board the cruizer a part of the crew of the fishing boat, in order to hand them over to the authorities of her nation.

ART. XXXI. The formal statement referred to in the preceding Article shall be drawn up in the language of the Commander of the cruizer, and according to the forms in use in his country. The accused and the witnesses shall be entitled to add, or to have added to such statement, in their own language, any observations or evidence which they may think suitable. Such declarations must be duly signed.

ART. XXXII. Resistance to the direction of Commanders of cruizers charged with the police of the fisheries, or of those who act under their orders, shall, without taking into account the nationality of the cruiser, be considered as resistance to the authority of the nation of the fishing boat.

ART. XXXIII. When the act alleged is not of a serious character, but has, nevertheless, caused damage to any fisherman, the Commanders of cruizers shall be at liberty, should the parties concerned agree to it, to arbitrate at sea between them, and to fix the compensation to be paid. Where one of the parties is not in a position to settle the matter at once, the Commanders shall cause the parties concerned to sign in duplicate a formal document specifying the compensation to be paid.

One copy of this document shall remain on board the cruiser and the other shall be handed to the master of the boat to which the compensation is due, in order that he may, if necessary, be able to make use of it before the Courts of the country to which the debtor belongs.

Where, on the contrary, the parties do not consent to arbitration, the Commanders shall act in accordance with the provisions of Article XXX.

ART. XXXIV. The prosecution for offences against or contraventions of the present Convention shall be instituted by, or in the name of, the State.

ART. XXXV. The High Contracting Parties engage to propose to their respective Legislatures any measures which may be necessary for insuring the execution of the present Convention, and particularly for the punishment by either fine or imprisonment, or by both, of persons who may contravene the provisions of Articles VI to XXIII, inclusive.

ART. XXXVI. In all cases of assault committed, or of willful damage or loss inflicted, by fishermen of one of the contracting countries upon fishermen of the other nationality, the Courts of the country to which the boats of the offenders belong shall be empowered to try them.

The same rule shall apply with regard to offences against and contraventions of the present Convention.

ART. XXXVII. The proceedings and trial in cases of infraction of the provisions of the present Convention shall take place as summarily as the Laws and Regulations in force will permit.

ART. XXXVIII. The present Convention shall be ratified. The ratifications shall be exchanged in London as soon as possible.

ART. XXXIX. The present Convention shall come into operation from and after a day to be fixed upon by the two High Contracting Parties after it shall have been notified by the Danish Government that measures have been passed in respect of the Faröe Islands and Iceland, by which freedom of navigation and anchorage within the territorial waters of the said islands is accorded to British fishermen (vide Article II, paragraph 3). The Convention shall continue in force until the expiration of two years from notice by either party for its termination.

The High Contracting Parties, however, reserve to themselves the power to make, by mutual consent, any modification in the Convention which experience shall have shown to be desirable, provided it is not inconsistent with the principles upon which the Convention is based.

ADDITIONAL ARTICLE. Any other Government, the subjects of which carry on fishery in the ocean surrounding the Faröe Islands and Iceland, may adhere to the present Convention. The adhesion shall be notified to one of the Governments at Copenhagen or at London, respectively. Such notification shall be communicated to the other signatory Power.

In witness whereof the Plenipotentiaries have signed the present Convention, and have affixed thereto their seals.

Done at London, in two copies, June 24, 1901.

APPENDIX G.

Award of the Paris Tribunal of Arbitration of 1893 with respect to Concurrent Regulations for the Protection of the Fur Seals outside the limits of exclusive jurisdiction.

ARTICLE 1. The Governments of the United States and of Great Britain shall forbid their citizens and subjects respectively to kill, capture, or pursue at any time and in any manner whatever, the animals commonly called fur seals, within a zone of sixty miles around the Pribilof Islands, inclusive of the territorial waters.

The miles mentioned in the preceding paragraph are geographical miles, of sixty to a degree of latitude.

ART. 2. The two Governments shall forbid their citizens and subjects respectively to kill, capture, or pursue, in any manner whatever, during the season extending, each year, from the 1st of May to the 31st of July, both inclusive, the fur seals on the high sea, in the part of the Pacific Ocean, inclusive of the Behring Sea, which is situated to the North of the 35th degree of North latitude, and eastward of the 180th degree of longitude from Greenwich till it strikes the water boundary described in Article 1 of the Treaty of 1867 between the United States and Russia, and following that line up to Behring Straits.

ART. 3. During the period of time and in the waters in which the fur-seal fishing is allowed, only sailing vessels shall be permitted to carry on or take part in fur-seal fishing operations. They will, however, be at liberty to avail themselves of the use of such canoes or undecked boats, propelled by paddles, oars, or sails, as are in common use as fishing boats.

ART. 4. Each sailing vessel authorised to fish for fur seals must be provided with a special license issued for that purpose by its Government and shall be required to carry a distinguishing flag to be prescribed by its Government.

ART. 5. The masters of the vessels engaged in fur-seal fishing shall enter accurately in their official log book the date and place of each fur-seal fishing operation, and also the number and sex of the seals captured upon each day. These entries shall be communicated by each of the two Governments to the other at the end of each fishing season.

ART. 6. The use of nets, firearms, and explosives shall be forbidden in the fur-seal fishing. This restriction shall not apply to shotguns when such fishing takes place outside of Behring's Sea, during the season when it may be lawfully carried on.

ART. 7. The two Governments shall take measures to control the fitness of the men authorized to engage in fur-seal fishing; these men shall have been proved fit to handle with sufficient skill the weapons by means of which this fishing may be carried on.

ART. 8. The regulations contained in the preceding articles shall not apply to Indians dwelling on the coasts of the territory of the United States or of Great Britain, and carrying on fur-seal fishing in canoes or undecked boats not transported by or used in connection with other vessels and propelled wholly by paddles, oars, or sails and manned by not more than five persons each in the way hitherto practised by the Indians, provided such Indians are not in the employment of other persons and provided that, when so hunting in canoes or undecked boats, they shall not hunt fur seals outside of territorial waters under contract for the delivery of the skins to any person.

This exemption shall not be construed to affect the municipal law of either country, nor shall it extend to the waters of Behring Sea or the waters of the Aleutian Passes.

Nothing herein contained is intended to interfere with the employment of Indians as hunters or otherwise in connection with fur sealing vessels as heretofore.

ART. 9. The concurrent regulations hereby determined with a view to the protection and preservation of the fur seals, shall remain in force until they have been, in whole or in part, abolished or modified by common agreement between the Governments of the United States and of Great Britain.

The said concurrent regulations shall be submitted every five years to a new examination, so as to enable both interested Governments to consider whether, in the light of past experience, there is occasion for any modification thereof.

APPENDIX H.

Konvention angående fiskeriförhållandena i de till Sverige och Danmark gränsande farvattnen; afslutad i Stockholm den 14 Juli 1899 och ratificerad i Marstrand den 4 Augusti samt i Köpenhamn den 21 Juli s. å.; ratifikationerna utvexlade i Stockholm den 10 November 1899.

Art. I. I de till konungarikena Sverige och Danmark gränsande farvattnen skall, med de i Art. II nämnda undantag, det område, hvarest fisket är uteslutande förbehållet hvartdera landets egna undersåtar, anses utåt hafvet sträcka sig en geografisk mil ($^1/_{15}$ breddgrad) från kusten eller ytterst derutanför liggande holmar och skär, som icke ständigt af vattnet öfversköljas.

Med sagda farvatten förstås i denna öfverenskommelse:

Kattegat, begränsadt mot norr af räta linier, dragna från Skagens nordligaste udde till Vinga fyr och vidare derifrån till närmaste kusten af Hisingen samt mot söder af räta linier, dragna från Hasenöre till Gniben och från Kullen till Gilbjerghoved;

Öresund, räknadt från Kullen-Gilbjerghoved i norr till Falsterbo-Stevns i söder;

samt *af Östersjön:* farvattnen längs svenska kusten från Falsterbo till Simbrishamn äfvensom kring Bornholm och Kristiansö.

Dock skall det vara medgifvet att drifva fiske: för svenska fiskare vid ön Anholt på ett afstånd af intill ¾ geografisk mil från kusterna af denna ö, och för danska fiskare på enahanda afstånd utanför en rät linie, dragen från Hallands Väderös fyr till Tylö fyr.

Art. II. I Öresund skall fiske allestädes vara tillåtet för båda ländernas undersåtar utan åtskilnad, dock med den inskränkning att vid stränderna å ömse sidor sundet innanför ett djup af sju meter det andra landets undersåtar icke må drifva annat fiske än sillfiske med garn. Likaledes skall vid Bornholms och Kristiansös kuster samt vid svenska kusten från Falsterbo till Simbrishamn sillfisket med drifgarn vara gemensamt för båda ländernas undersåtar från den 1 Maj till den 31 Augusti.

Strand- och fiskerättsegare förbehållas de särskilda rättigheter, som dem jemlikt hvartdera landets lagar och författningar kunna tillkomma.

Art. III. Det skall vara båda ländernas fiskare tillåtet att, utan intrång i enskild rätt och under iakttagande af gällande tullföreskrifter samt andra

Convention regarding fishery relations in the navigable waters bordering on Sweden and Denmark. Concluded at Stockholm on July 14, 1899, and ratified at Marstrand on August 4 and at Kopenhagen on July 21 of the same year; ratifications exchanged at Stockholm on November 10, 1899.

Art. I. In the navigable waters bordering on the Kingdoms of Sweden and Denmark the region in which fishing is exclusively reserved to the subjects of each respective country shall, with the exceptions mentioned in Article II, be considered to extend out into the sea one geographical mile [=4 English miles], or $^1/_{15}$ degree of latitude, from the coast or from the farthest island or rock lying off shore and not permanently covered by water.

By said navigable waters are meant in this treaty:

Kattegat, bounded on the north by a straight line drawn from the northernmost point of Skagen to Vinga lighthouse, thence to the nearest coast of Hisingen, and on the south by a straight line drawn from Hasenöre to Gniben and from Kullen to Gilbjerghoved.

The Sound, reckoned from Kullen-Gilbjerghoved on the north to Falsterbo-Stevns on the south.

The Baltic: The navigable waters along the Swedish coast from Falsterbo to Simbrishamn, as well as around Bornholm and Kristiansö.

Nevertheless Swedish fishermen shall be allowed to fish at Anholt Island a distance of ¾ geographical mile [=3 English miles] from the coasts of said island, and Danish fishermen shall be allowed to fish a like distance beyond a straight line drawn from Hallands Väderös lighthouse to Tylö lighthouse.

Art. II. In the Sound fishing shall be allowed everywhere to the subjects of both countries without distinction, provided, however, that on the shores on each side of the Sound within a depth of 7 meters the subjects of the other country shall not engage in any fishing except for herring with nets. Likewise, on the coasts of Bornholm and Kristiansö, as well as on the Swedish coasts from Falsterbo to Simbrishamn, herring fishing with drift nets shall be allowed to subjects of both countries from May 1 till August 31.

To owners of shores and fishing rights are reserved the special privileges which may belong to them according to the laws and constitution of either country.

Art. III. The fishermen of both countries shal be allowed, without encroaching on private rights and observing the customs regulations as well as

dylika bestämmelser, ej mindre i Öresund än äfven å de enligt Art. I hvartdera landet förbehållna fiskeområdena fritt färdas och ankra.

ART. IV. Vid fiskets bedrifvande skola båda ländernas fiskare iakttaga att, sedan någon intagit en fiskeplats och behörigen utmärkt sin redskap, han icke må, så länge han har sin redskap behörigen utmärkt och begagnar densamma till fiske, utträngas derifrån eller lida intrång i sitt fiske af andra fiskare.

Sättes eller drifver fiskredskap på annan mans behörigen utmärkta redskap, eller drages not (vad) så, att behörigen utmärkt redskap skadas, skall dennes egare hafva rätt till ersättning af den, som tillfogat honom sådan skada, så framt icke skadan skett genom nödtvång eller annan orsak, som ej kan tillräknas denne.

För att redskap skall anses vara behörigen utmärkt, skola följande regler vara iakttagna:

1) *Bottengarn, ålhommesätt* ("ålestader"), *räkrusor, strandsätt för lax* och annan dylik redskap, som är fästad vid pålar, skall vid hufvudpålen eller den yttersta pålen vara försedd med en mörk flagg, som når minst en och en half meter öfver vattnet.

2) *Ryssjor* (hommor), som icke äro fästade vid pålar, skola, när de sättas spridda, hvar för sig vara utmärkta med en upprättstående stake utan topptecken, hvilken räcker minst tolf decimeter öfver vattnet. Utsättas ryssjorna (hommorna) i rad, kan afmärkningen inskränkas till en sådan stake för de två yttersta ryssjorna i raden och en boj eller mindre stake för hvar och en af de öfriga ryssjorna.

Tinor skola vara utmärkta genom en flytande träklabb.

3) För *annan fastående redskap*, vare sig densamma är bottensatt eller flyter närmare ytan, skall vid hvardera ändan af länken anbringas en stake, med eller utan tunna, hvars topp räcker minst tolf decimeter öfver vattnet och är utmärkt med en flagga, tre decimeter i fyrkant, för den ända af länken, som står i kompassens östliga halfcirkel (från norr genom ost till syd), samt två trekantiga, tre decimeter långa flaggor för den ända, som står i kompassens vestliga halfcirkel (från syd genom vest till norr). Mellan dessa märken skall anbringas en mindre stake utan topptecken eller en boj för minst hvar nio hundra fyrtionde meter.

4) *Snurrevadar* (strykvadar *och drifvadar* skola vid notpåsen eller kalfven (kilen) vara försedda med bojlina samt en svartmålad kagge eller boj utan topptecken. Vid fiske med snurrevad skall

other similar regulations in force, to navigate freely and to anchor both in the Sound and the fishing regions reserved in accordance with Article I to each country.

ART. IV. In engaging in fishing the fishermen of both countries must remember that, when a fishing ground has been taken up and the tackle is properly marked, the occupant is not to be driven away or suffer any encroachment in his fishing by other fishers as long as his tackle is properly marked and he uses it for fishing.

If fishing tackle is placed or drifts upon the properly marked tackle of another fisherman, or if a seine is so dragged as to injure properly marked tackle, the owner of such tackle shall be entitled to damages from the person who has caused him such injury, provided the damage was not caused by unavoidable necessity or other cause which can not be attributed to such owner.

In order that tackle may be considered as being properly marked, the following rules must be observed:

1. Bottom nets, eel traps (alhommesätt), shrimp traps (räkrusor), shore weirs (strandsätt) for salmon, and other similar tackle fastened with poles, must have attached to the principal pole or the outermost pole a dark flag reaching at least 1½ meters above water.

2. Lobster traps (hommor) which are not fastened with poles shall, when they are set out, each be designated by an upright stake without top mark, reaching at least 12 decimeters above water. If the traps are set out in a row, the marking can be limited to such a stake for the two outermost baskets in the row and a buoy or lesser stake for each of the other baskets.

Single pots should be marked by a floating log.

3. In the case of other stationary tackle, whether it be laid on the bottom or float nearer the surface, there shall be a stake at each end, with or without cask, the top of which shall reach at least 12 decimeters above water and be marked with a flag 3 decimeters square, at the end of the chain situated in the eastern semicircle of the compass (from north through east to south), and two triangular flags 3 decimeters long at the end situated in the western cemicircle of the compass (from south through west to north). Between these marks there shall be placed a lesser stake without top mark, or a buoy, at least every 914 meters.

4. Seines (snurrevadar) and drift nets (drifvadar) must be provided, at the bag or cod, with a buoy line and a black-painted keg or buoy without top mark. In fishing with a seine a stake with

från fartyget vara utsatt en stake med blå flagg i den rigtning, hvari vaden är utsatt.

5) *Drifvande eller svajande redskap* skall vid den fasta ändan af länken, som är förankrad vid botten eller fastgjord vid båten, utmärkas med en boj utan stake, samt vid den fria ändan med en boj med stake, som räcker minst tolf decimeter öfver vattnet.

Drifvande redskap skall, när fisket sker i Öresund, om natten föra en hvit lanterna pä denna stake; svajande redskap skall föra en trekantig flagg.

6) Inga fiskemärken, utom de i 1) nämnda, må räcka högre öfver vattnet än en och en half meter.

ART. V. Det i Art. IV nämnda skydd för fastående redskap gäller beträffande omkring Bornholm och Kristiansö utsatta laxlinor eller laxrefvar endast från och med den 1 Oktober till den 1 April.

ART. VI. Artiklarna IV och V hafva afseende å farvattnen utanför de hvartdera landet förbehållna fiskeområdena samt jemväl å de platser, der fiske enligt Art. II är gemensamt för begge rikenas undersåtar.

ART. VII. Öfverträdelser af de i artikel IV gifna föreskrifter skola, för såvidt de angå handlingar begångna utanför det hvartdera landet förbehållna fiskeområdet, äfvensom i Öresund på större afstånd än en geografisk mil från närmaste land, ö eller skär, som icke ständigt öfversköljes af vatten, straffas med böter från och med tio till och med tvåhundra kronor.

ART. VIII. Öfverträdelser, som i artikel VII omförmälas, åtalas och afdömas i det land, hvartill den skyldiges fartyg hörer.

ART. IX. De farkoster, som idka fiske i de farvatten, denna öfverenskommelse omfattar, skola vara tydligt märkta med nummer och stationsmärke, såväl å skrofvet som å storseglet.

ART. X. De båda ländernas regeringar förpligta sig att underrätta hvarandra om de åtgärder, som vidtagas för tillsynen öfver efterlefnaden af de i denna öfverenskommelse meddelade bestämmelser.

ART. XI. Denna konvention skall träda i kraft genast efter det ratifikationerna utvexlats och förblifva gällande intill dess sex månader förflutit från den dag, då endera af de höga parterna uppsagt densamma.

Till bekräftelse häraf hafva de respektive fullmägtige undertecknat denna konvention och försett densamma med sina sigill.

Som skedde uti två exemplar i Stockholm den 14 Juli 1899.

blue flag shall be set out from the boat in the direction in which the seine is set out.

5. Drifting or swinging tackle shall, at the fast end of the chain which is anchored on the bottom or fastened to a boat, be designated with a buoy without stake, and at the free end by a buoy with stake, reaching at least 12 decimeters above water.

Drifting tackle shall, when the fishing is done in the Sound, be provided at night with a white lantern on this stake; swinging tackle shall carry a triangular flag.

6. No fishing marks, except those mentioned under No. 1 above, shall reach higher than 1½ meters above water.

ART. V. The protection to stationary tackle mentioned in Article IV applies to salmon fish-lines placed out around Bornholm and Kristiansö only from October 1 to April 1.

ART. VI. Articles IV and V relate to the navigable waters beyond the fishing regions reserved for each country, as well as to the places where fishing is permitted alike to the subjects of both countries in accordance with Article II.

ART. VII. Violations of the provisions of Article IV shall, if committed outside the fishing regions reserved to each country, or in the Sound over four geographical miles from the nearest land, island, or rock not constantly covered by water, be punishable by a fine not less than 10 and not exceeding 200 crowns.

ART. VIII. Violations as mentioned in Article VII shall be prosecuted and punished in the country to which the boat of the guilty party belongs.

ART. IX. Vessels which engage in fishing in the navigable waters embraced in this convention shall be distinctly marked with a number and station mark, both on the hull and on the mainsail.

ART. X. The governments of both countries pledge themselves to inform each other of the measures adopted for the purpose of insuring the observance of the provisions contained in this convention.

ART. XI. The present convention shall go into force immediately after the exchange of ratifications and shall remain in force until six months after one of the high contracting parties has repudiated it.

In witness whereof the respective plenipotentiaries have signed this Convention and affixed thereto their seals.

Done in two copies at Stockholm, on the 14th day of July, 1899.

PROTOKOLL.

1. Till närmare bestämmande af den enligt art. X af den mellan H. M. Konungen af Sverige och Norge och H. M. Konungen af Danmark denna dag afslutade fiskerikonvention förutsatta tillsynen öfver konventionsbestämmelsernas efterlefnad hafva, efter dertill af regeringarne lemnadt bemyndigande, undertecknade, jemte förklarande att det ena landets fiskeritillsyn ej må sträckas in på det andra landets område, eller å farvatten, som ligger utanför det hvartdera landet förbehållna fiskeområdet, utöfvas mot andra än landets egna undersåtar, vidare afgifvit följande särskilda förklaringar.

Svenska regeringen förklarar sig vilja dels anbefalla vederbörande länsstyrelser förständiga sina underordnade att hälla noggrann uppsigt öfver att de i konventionens särskilda artiklar gifna bestämmelser icke af enskilde öfverträdas, dels ock söka, i den mån förhållandena det medgifva, bereda ytterligare anordningar för öfvervakande af att konventionens föreskrifter varda af de svenske undersåtarne vederbörligen iakttagna, och svenska regeringen har för sådant ändamål särskildt tänkt sig, att den kanonbåt, som under höst- och vintermånaderna plägar vara stationerad vid bohuslänska kusten, skulle kunna beordras att, då dess närvaro derstädes under dessa månader ej erfordras, och omständigheterna i öfrigt derför ej lägga hinder i vägen, besöka de i konventionen afsedda fiskeområdena för att utöfva ifrågavarande fiskeritillsyn, eller ock att, i den mån nödiga medel af Riksdagen anvisas, samma eller annan kanonbåt skulle äfven under andra tider af året for ändamålet användas.

Danska regeringen förklarar sig vilja träffa de för öfvervakande af konventionens bestämmelser och med hänsyn till polistillsynen nödvändiga åtgärder.

2. Vidare hafva undertecknade, dertill vederbörligen bemyndigade, öfverenskommit, att, derest mellan de kontraherande magterna meningsskiljaktigheter om tolkningen eller tillämpningen af konventionen uppstå och dessa icke kunna genom diplomatiska förhandlingar utjemnas, desamma skola hänskjutas till skiljedom.

Till yttermera visso hafva undertecknade underskrifvit detta protokoll i tvenne lika lydande exemplar och bekräftat detsamma med sina sigill, som skedde i Stockholm den 14 Juli 1899.

DEKLARATION.

Hans Majestät Konungen af Sverige och Hans Majestät Konungen af Danmark hafva bemyndigat undertecknade att afgifva följande deklaration:

PROTOCOL.

1. In order to determine more precisely the vigilance to be exercised, for insuring the observance of the provisions of the fishery convention concluded this day between H. M. the King of Sweden and Norway and H. M. the King of Denmark, in accordance with Article X of said convention, the undersigned, being empowered for the purpose by their Governments, have declared that the supervision over fishery exercised by one country shall not extend over the territory of the other country nor be exercised against the subjects of the other country on the navigable waters lying outside the fishing regions reserved to each country, besides which they have made the following special declarations:

The Swedish Government declares its willingness to order the respective district governments to exercise strict vigilance to prevent violation of the various provisions of the convention by private individuals, and it will endeavor, to the extent that circumstances permit, to prepare further regulations for the purpose of insuring the due observance of the provisions of the convention by Swedish subjects, for which purpose it has particularly deemed that the gunboat usually stationed during the fall and winter months along the coast of Bohuslän might be ordered, when its presence there during these months is not required and when other circumstances do not oppose, to visit the fishing regions set off in the convention in order to exercise the necessary vigilance over the fishing, or else, to the extent that the necessary funds may be provided by the Parliament, that the same or another gunboat might be employed for the purpose even during other seasons of the year.

The Danish Government declares itself willing to take the necessary steps to execute the provisions of the Convention and to maintain police supervision.

2. The undersigned, duly authorized, have furthermore agreed that in case of diversity of opinion between the contracting powers as to interpretation or execution of the provisions of the Convention, when such diversity can not be adjusted by diplomatic measures, the matter shall be submitted to arbitration.

In witness whereof the undersigned have signed this protocol in two copies and affixed their seals on same.

Done at Stockholm on the 14th day of July, 1899.

DECLARATION.

His Majesty the King of Sweden and His Majesty the King of Denmark have authorized the undersigned to make the following declaration:

ART. I. Art. II af den under den 14 juli 1899 i Stockholm afslutade konvention angående fiskeriförhållandena i de till Sverige och Danmark gränsande farvattnen erhåller följande förändrade lydelse:

I Öresund skall fiske allestädes vara tillåtet för båda ländernas undersåtar utan åtskillnad, dock med den inskränkning att vid stränderna å ömse sidor Sundet innanför ett djup af sju meter det andra landets undersåtar icke må drifva annat fiske än sillfiske med garn. Såsom drifgarn vid sillfiske få endast *närdingar* användas. Utanför den nämnda sjumetersgränsen i Öresund är allt slags fiske med trawl och vad förbjudet.

På Middelgrundet är det likväl tilllåtet att begagna agnnot. Med agnnot förstås sådan not, å hvilken armarnas längd tillsammans icke öfverskrider 7½ meter (4 famnar).

Vid Bornholms och Kristiansös kuster samt vid svenska kusten från Falsterbo till Simrishamn skall sillfisket med drifgarn vara gemensamt för båda ländernas undersåtar från den 1 maj till den 31 augusti.

Strand- och fiskråttsägare förbehållas de särskilda rättigheter, som dem jämlikt hvartdera landets lagar och författningar kunna tillkomma.

ART. II. Rödspätta, som i totallängd icke håller 25½ centimeter (21 centimeter från nosspetsen till stjärtroten), må ej finnas ombord i fartyg eller båt, som befinner sig i Kattegatt med dess vikar och fjordar på fiske eller för fiskhandel, och ej heller vid kusterna af Kattegatt med dess vikar och fjordar föras i land, hållas till salu eller utbjudas, säljas eller från ort till annan forslas, utan skall sådan rödspätta, därest den varder vid fiske upptagen i farkost eller på land, snarast och så vidt möjligt i oskadadt tillstånd i hafvet åter utsläppas.

För Öresund gälla samma bestämmelser, dock må, med undantag för det till städerna — å svenska sidan Hälsingborg, Landskrona och Malmö, å danska sidan Helsingör och Köpenhamn — hörande vatten- och landområde, i Sundet fångad rödspätta, som i totallängd håller minst 21 centimeter (17 centimeter från nosspetsen till stjärtroten), finnas ombord och föras i land för att förbrukas inom någon af de Öresunds kuster närmast belägna kommuner.

ART. III. Denna deklaration träder i kraft den 1 november 1907.

Till bekräftelse häraf hafva undertecknade underskrifvit denna öfverenskommelse och försett densamma med sina sigill.

Som skedde i Stockholm i två exemplar den 5 oktober 1907.

ART. I. Article II of the convention concluded at Stockholm on July 14, 1899, regarding fishery relations in the navigable waters bordering on Sweden and Denmark, is modified so as to read as follows:

In the Sound fishing shall everywhere be allowed the subjects of both countries without distinction, provided, however, that on the shores on both sides the Sound within a depth of 7 meters the subjects of the other country shall not engage in any other fishing than herring fishing with nets. Only "närdingar" may be used as drift nets in herring fishing. Outside the aforementioned 7-meter limit in the Sound all kinds of fishing with trawls or seines is forbidden.

On the Middle Ground (Middelgrund) the use of bait-nets shall also be permitted. As bait-nets are included nets in which the length of the arms does not exceed altogether 7½ meters (4 fathoms).

On the coasts of Bornholm and Kristiansö, as well as on the Swedish coast from Falsterbo to Simrishamn, herring fishing with drift nets shall be permissible to the subjects of both countries from May 1 to August 31.

Owners of shores and fishing rights shall retain the privileges to which they are entitled under the laws and constitutions of each country.

ART. II. Plaice which do not measure 25½ centimeters in total length (21 centimeters from tip of nose to base of tail) must not be found on board any vessel or boat engaged in fishing or in dealing in fish in the Kattegatt, its coves or fjords, nor shall they be imported on the coasts of the Kattegatt, its coves or fjords, or be kept for sale or offered for sale or sold, or conveyed from one place to another, but such plaice when caught while fishing, from a boat or from shore, shall be thrown back into the sea as soon as possible and as far as possible unhurt.

The same rules apply to the Sound; nevertheless, with the exception of the adjacent water and land at Hälsingborg, Landskrona, and Malmö on the Swedish side and Helsingör and Köpenhamn on the Danish side, plaice caught in the Sound and measuring at least 21 centimeters in total length (17 cm. from tip of nose to base of tail), will be allowed on board and may be imported for consumption in some of the communes lying nearest the coasts of the Sound.

ART. III. This declaration goes into effect November 1, 1907.

In witness whereof the undersigned have signed this agreement and affixed thereto their seals.

Done at Stockholm in two copies on the 5th day of October, 1907.

DISCUSSION.[a]

Mr. OLSEN. I have listened with very great interest to this excellent paper. A better one I do not think we shall be able to hear in this assembly, for it touches the chord of everything that affects the regulations of the fisheries on the high seas. With regard to Moray Firth, which the speaker referred to, I am sorry to stand here and confess that we have to-day about thirty English steam trawlers sailing under foreign flags, for the simple purpose of poaching in the Moray Firth. It seems to me disgraceful that such things should be done; but, on the other hand, it is quite right that the Moray Firth should be open to trawling, inasmuch as the 3-mile limit is considered and that the bay which they have drawn the line across is something like 90 miles in width, contains a great area of water, and that that piece of water is open to all nations, according to the convention of 1882. The poaching (I can not call it anything else) is certainly a very mean way of trying to avoid the law by putting the vessel under another flag. Such things I have personally objected to. This bone of contention, trawling in the Moray Firth, is a thing that the British Government can not legally enforce nor prevent, for it is not the property of the British nation, since it was agreed to in the convention of the contracting parties. It belongs to the convention only to police, and not to one country. I think it impossible either for this congress or for any other congress to induce the British Government to give up that piece of water. The only way I can conceive is that a tribunal, an international society, be formed for the purpose of adjusting all kinds of grievances respecting the fishery laws, etc., and that this society be able to so formulate the requirements as to bring it before the Government in question, with a lot of influence behind it to induce the home governments to legislate for the fishermen and all those engaged in the industry.

Mr. FRYER. Mr. President, ladies, and gentlemen, the very important diplomatic issues involved in the paper read before us just now, and especially in reference to the case of the Moray Firth in Scotland, are so serious that I feel I can not properly deal with them in the short space of time at our disposal this morning; but I think that one little explanation is necessary on the point of the apparently doubtful position which the United Kingdom has assumed in regard to jurisdiction beyond the 3-mile limit.

The facts are as stated in the paper; but one simple point was omitted, and that is in reference to the peculiar position of the boat against which the proceedings in the case referred to were taken. The justification for the apparent exercise of sovereign rights over a foreign vessel at a distance of more than 3 miles from low-water mark was found in the fact that this vessel was manned mainly by British subjects. The law in question was a domestic law; it was aimed at British subjects; and it was felt to be an improper thing that by the mere transfer of a ship from the British to a foreign flag, and by the employment of British subjects as fishermen, that vessel should be able to escape the purely domestic municipal law of the country which made it. This was the ground upon which the apparently inconsistent attitude of the British Government was justified and maintained in the high court in Scotland. The question has not reached its ultimate solution yet, but the position is so exceedingly delicate, and involves so many important diplomatic considerations—being, in point of fact, now the subject of diplomatic intercourse between the several nations of Europe which are fishing in this water—that I do not propose to enter further into it; especially seeing that, although I happen to be an

[a] As this paper was not read in full, the discussion pertains only to points treated in the abstract.

official of the British Government, I have no official authority here, and have no right to say anything in any way on behalf of my country, and I should hesitate to say a word which might be held to be anything like an official statement in the matter. However, I thought it necessary to point out that there was a reason for the apparently inconsistent attitude taken by my country in the premises.

With respect to one main question involved in the paper before us, namely, that the extension of the territorial limits was apparently necessary in order to give encouragement to the cultivation of the sea bed, in regard to such fisheries as those for shellfish, I would point out that the range covered by the existing limits is already sufficiently wide, without going further afield and giving proprietary rights beyond the 3-mile line. There are very few cases in which fisheries for shellfish, especially, are carried on to such an extent as to justify any proposal for placing any wider area of the sea bed under proprietary jurisdiction.

WORK OF THE INTERNATIONAL FISHERIES COMMISSION OF GREAT BRITAIN AND THE UNITED STATES

By David Starr Jordan

International Fisheries Commissioner

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

WORK OF THE INTERNATIONAL FISHERIES COMMISSION OF GREAT BRITAIN AND THE UNITED STATES.

By DAVID STARR JORDAN,
International Fisheries Commissioner.

The International Fisheries Commission represents a most interesting effort to settle at once a number of problems in international law, in constitutional law, in conflict of laws, in equity, and at the same time in biology, for no statute for the preservation and propagation of fishes can be effective unless the nature of the individual species, its food, its distribution, and its habits are primarily and persistently kept in view.

The boundary waters of the United States and Canada include two of the greatest fishing areas of the world. The Great Lakes constitute the greatest body of fresh water belonging to any single system, and are richer in fish life than any other. Puget Sound and the adjacent waters are part of the great Alaskan system, the region of all the world richest in salmon.

In these boundary waters the statutes of the Dominion of Canada, those of the different Provinces, and those of the different States of the American Union are more or less at cross-purposes with each other. Over Lake Erie, for example—the richest of the lakes in fisheries—four States and one Province claim jurisdiction, with the greatest variation in theory and practice of fish protection. In the treaty of April 11, 1908, an attempt is made to remedy this condition of affairs by the adoption by Great Britain and the United States of identical statutes relating to the fisheries, these statutes to hold for a period of four years without change, except by the joint action of both nations. Under this treaty two commissioners have been appointed to draw up this code of fishery statutes. These are Hon. Samuel Tovel Bastedo, of Toronto, as representative of Great Britain, and the present writer as representative of the United States. It is agreed that the code shall be submitted to both nations for adoption by the 1st of January, 1909.

This treaty involves a number of interesting principles: (1) Joint international action in the case of migratory animals moving from waters of one nation to those of another, in place of national control on the two sides of the boundary; (2) substitution of international legislation in this regard for that of the several

Provinces, States, and counties; (3) the code of statutes must depend on the nature of the different species of animals it is designed to protect, the matter becoming, at bottom, one of natural history.

In nearly all cases the final key to the situation is found in artificial propagation—the development of the hatchery. This demands, however, men who are willing to study their business and to learn thoroughly the nature of the fishes concerned—the egg, the fry, and the adult. Artificial hatching is not a process. It is an art, and like all arts it must rest on science. How much of the money spent on hatcheries has been wholly wasted no one can tell, but the amount is considerable. And the value of any hatchery is determined, not by the nominal output of eggs and fry but by the brains put into the business. Each species of fish, like each plant in the garden, has its own nature and must be met on its own ground. It is set in its ways and will not conform to the habits of any other species.

The species of fishes affected by this legislation are numerous, but they can be grouped into about six types, as represented by the herring, the whitefish, the red salmon of the Pacific, the black bass, the wall-eye, and the sturgeon.

The herring is a marine fish existing in incalculable numbers and swarming by the million in many places on both shores of the North Atlantic. The catch of herring in navigable waters is less than a drop in the bucket, and the fishery statutes must concern the protection and regulation of the fishing industry rather than the conservation of the herring itself.

The whitefish is a type of a group of fishes, part of them the helpless prey of the predatory fishes, the rest feeding freely on other forms, but all spawning in cooling waters, mostly in November. The eggs are large, free, and easily manipulated, so that they can be readily cared for by processes of artificial propagation. By caring for these eggs, perhaps twenty times as many young can be returned to the lake as would develop naturally. The best protection to such fishes is that of a size limit, forbidding the buying or selling of all that have not reached the degree of maturity involved in the second appearance on the spawning grounds. These fishes are fit for the table while the spawning process is going on. To forego catching them for a month or so before the spawning period, then to allow free fishing for adult fish on the part of those fishermen prepared to preserve the spawn is the best means of maintaining and increasing fisheries of this type. By this process the adult fishes are regarded as a ripened crop, which is removed to make way for the crop of next year. In this regard we already see every prospect of success in the Great Lakes, as even under present conditions, with the present hatchery facilities, the number of fishes of this kind is steadily increasing.

To another category belongs the salmon of the Pacific coast, which feed in the sea, spawn in the rivers, ascending the streams for the most part when

4 years old, all individuals, male and female, dying soon after the first spawning. In this case the fish are valuable only when about to leave the sea, or in the lower courses of the rivers. When the spawn and milt is ripe the flesh of the fish is worthless. Here the problem is to allow fish enough to escape the nets and to ascend the rivers to cover the spawning grounds and to keep the hatcheries occupied. The most valuable of these species in international waters, the red salmon, spawns only in streams at the head of lakes. In Puget Sound the supply has been greatly depleted by overfishing. Under such circumstances nothing is gained by statutes regulating the size of fish. The only thing to be done is to establish seasonal or weekly closed periods, when a certain large number shall have opportunity to pass up to the lakes. In this case, nearly all the spawning grounds are in Canadian territory in the tributaries of Fraser River.

The black bass is the type of still another group of fishes. The male bass maintains his own hatchery. The eggs can not be stripped and hatched by artificial means. The male fish builds a nest, and the fertilized eggs are deposited in it. Then he stands guard over them, driving away all intruders, including the mother bass, until the hatching is complete. Then he eats some of his own young—let us hope the least active, as a contribution to natural selection—while the rest escape. No artificial improvement over his method is possible. In this case protection consists in preventing the catching of the immature fish and the absolute preservation of the spawning grounds from intrusion of net or hook.

Another class contains predatory fish like the wall-eye and perch, spawning in spring in warming waters, but susceptible of assistance through artificial hatching. In general, these are adequately protected by the law of the size limit, by which the immature fishes are kept from the markets. Sometimes, however, nets must be kept out of the line of their spring migrations.

Still another class is composed of the sturgeon. It reaches a great size, and when running to its spawning beds in the spring is an easy victim to the pot hunter. The vast majority of the sturgeons in our lakes have been killed for the eggs, which are made into caviar. The sturgeon thus far has resisted the attempts at artificial propagation, by reason of certain peculiarities of its own. When ripe the eggs and milt are thrown as soon as the fish is touched. When the eggs and milt are unripe they die without maturing if the fish is confined in a pond. With the sturgeon there is but one method of artificial increase—to prevent all killing for a series of years, corresponding to the years of unlimited slaughter.

To protect for their greatest usefulness the varying groups of fishes, in all the lakes, rivers, and seas of our northern boundary, is the task of the International Fisheries Commission. In so far as this commission is successful, it

should extend the fisheries, increase the amount of available fish food, and bring about a more harmonious relation between the United States and Canada. Furthermore, it should improve the lot of each individual fisherman. If the work is successful it should furnish models for the statutes of the different States and Provinces which have like problems and like interests.

If this international project is carried out satisfactorily, the same remedy should be applied to the difficulties arising from the migration of fishes in interstate waters. The conditions are the same in Lake Michigan, controlled by the variant statutes of four States, as in Lake Erie with her five States and Provinces.

The problem of the Columbia with its magnificent fisheries at the mercy of the inadequate, greedy, and variant statutes of Oregon, Washington, and Idaho, is far more difficult and more hopeless than that of the Fraser River and Puget Sound.

Twenty-eight years ago in my report on the salmon fisheries of the Columbia I called attention to the fact that these fisheries would be depleted or destroyed unless the Government of the United States could intervene between Oregon and Washington. In each State fishermen try to take all they can get and the two legislatures can never agree on joint action of any kind adequate for the protection of the species. This has gone on from bad to worse until the Columbia fisheries are but a fraction of what they were in 1880. At the present time, under the referendum laws of Oregon, all fishing above tidewater is forbidden in Oregon, and all gill-net fishing by night below tidewater limit is also prohibited. This practically closes all fishing on the Oregon side, while on the Washington side and in the spawning grounds of Idaho there is no limit of any kind. These statutes may be set aside by the courts—one or both of them—but meanwhile very few fishes reach the spawning grounds, and the fisheries four years hence will amount to nothing. All this comes from a struggle, carried into politics, between the associated (gill net) fishermen on the one hand and the owners of the fish wheels up the river on the other.

The fisheries in the other boundary waters, Lake Michigan, the Mississippi, the Ohio, and the Potomac, are all in similar bad way. For this there is no remedy evident except for the United States to take control of all migratory animals of commercial value and to control and legislate for the interstate fisheries as it does for the interstate commerce and for the interstate weather. Matters of importance which no particular State can manage should be taken in hand by the United States. Problems which seesawing legislatures find insoluble because they can not agree on joint action are easy enough to a national commission. In this case the machinery for investigation and control (and all control must be based on scientific investigation) already exists in the United States Bureau of Fisheries.

SOME REASONS FOR FAILURE OF FISH PROTECTIVE LEGISLATION AND SOME SUGGESTED REMEDIES

By Oregon Milton Dennis

Former State Game Warden of Maryland

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

SOME REASONS FOR FAILURE OF FISH PROTECTIVE LEGISLATION AND SOME SUGGESTED REMEDIES.

By OREGON MILTON DENNIS,
Former State Game Warden of Maryland.

Mr. PRESIDENT, LADIES, AND GENTLEMEN: In speaking on this subject I want it distinctly understood in the beginning that, while my language will appear to be harsh and my criticism severe with reference to some causes for the failure of the passage of proper and effective fish protective legislation, I am dealing with this subject in generalities, and without particular reference to any person or protective association. I have come to the conclusions which follow after very mature deliberation, and shall deal with this, as I have with every other matter with which I have had to do, in an honest and fearless manner, my sole purpose being to aid in fish protection and to point out some of the reasons why it has failed. A long experience as secretary and counsel of a large protective association and as the state game warden of Maryland, as well as my legislative experience, has, I believe, fully qualified me to express some opinions on the subject-matter of this paper. Of course, this experience has been gained in my own state, and what I shall say will deal largely with the conditions in that state.

The political division of Maryland through the representation of county members in the legislature places the control of legislation within the power of the counties; notwithstanding the fact that while about one-half of the population is centered in Baltimore city the latter has only about one-fourth of the delegates. I mention this because protective influences originate very largely in the city, and the state's chief protective association is there, composed of men who, whether intelligently or not, frame the bills that are presented to the legislature for action. I say intelligently, because while this association includes some of the wealthiest and best of our citizens, its enthusiasm for protection of both game and fish and the bills framed by it are largely based on the selfish reasons of sportsmen, and largely without regard to intelligent conclusions with reference to the rights of the commercial fishermen, whose vote is sufficiently large in tide-water sections of our state to control the electorate. This being

true, the county members of the legislature, as well as the fishermen themselves, look with suspicion upon any measure presented to the legislature which has for its purpose the protection of fish and game when such measure is presented by city men.

Growing out of this condition (about two years ago) a fishermen's protective association was formed in Maryland for the distinct purpose of fighting the city association, on the ground that the latter was unfair and that its only interest in protection, it was believed, was to secure to the angler a good day's fishing without regard to the commercial fisherman's interest. This condition grew out of a policy of the game protective association of introducing measures abolishing the use of all sorts of nets, or so restricting their use that the commercial fisherman would be put out of business. I am happy to say, however, that during the past year, I believe largely through my own efforts as state game warden, the two associations have united on a number of measures for fish protection, though without specific results.

Unfortunately, the selfish interest of one class and the suspicions of another are largely the reason for the failure of proper fish protective legislation. The angler goes to the legislature with a bill based on his idea of what the law should be, and that idea is usually the prohibition of the use of all sorts of nets which will interfere with his sport; an other class, the commercial fishermen, prepare a bill to protect them in the use of the sort of nets with which they fish, and still another set of fishermen have a bill to protect them in their method. The result is that the legislative committee before whom these bills go is pulled and hauled and besieged and worked upon by the various interests to such an extent that it becomes disgusted and pigeonholes all the bills, so that none is passed.

Another reason is that while the state of Maryland spends thousands of dollars for fish culture it persistently refuses to make any appropriation for, or to give the state warden department any material assistance in, the enforcement of such laws as we now have; and while the state navy is charged by law to enforce the laws for fish protection, the character of its boats prevents them from going into shallow waters to do any work even if time permitted to divert the boats from oyster protection to do this.

What I have said above is but the foundation for specific reasons which I shall give for failure of protective legislation, and which in my opinion can be reduced to the following, to wit:

1. Up to this time it has been absolutely impossible to get the tide-water fishermen to agree on any bills, and, in my judgment, even if proper laws were enacted, under the system in our state they would absolutely fail of enforcement.

2. I declare, next to the above reason, that the greatest reason for non-passage of fish protective bills is the action and influence of the duck gunners

of Maryland, who, either by purchase or by lease, secure absolute control of water fronts in the tide-water counties for their ducking clubs and shooting grounds. These gentlemen, among the foremost citizens of our state, and largely residents of the city, are jealous of the rights that they claim they have paid for, and in order that they may preserve them are in constant conflict with the resident fishermen, who ply their industry in the waters fronting or adjacent to these shores. Against these men of wealth and influence there is small opportunity to prevail with the legislators when there is a conflict between the rights of the duckers and the fishermen.

There are a number of other reasons which, in my opinion, prevent the passage of proper fish protective laws, but these are sufficient for my purpose.

Now as to the remedy. I shall offer but one, but I think it will be sufficiently radical to bring down on my head all the knocks that I can stand up under. You will remember that I made this suggestion at the last annual meeting of the American Fisheries Society:

Admitting the necessity for protection of young fish after they have been placed in the waters by the States and the United States, the question that confronts us is, how? I believe that, if it comes within the constitutional powers of the Government, Congress should pass proper interstate laws for the protection of fish.

Thousands of dollars are being spent, practically wasted, for fish propagation in Maryland. The state has persistently neglected to provide for protection. Not until after fifty years of constant agitation and the practical extermination, commercially, of the oyster, has Maryland been awakened (and that but two years ago) to the fact that the oyster in Maryland must be protected or exterminated. If it has taken this long to awaken to the serious condition of the oyster, how long will it take to recognize the necessity for the protection of the fish, and thus save to the people of our own state and other communities and from extermination one of the greatest natural food products of the world?

Mr. Bryan, at the conference of the governors of the states held in May last in Washington, had this to say with reference to the protection of the great natural resources of the country—that he regarded "the development of water transportation as essentially a national project, because the water courses run by and through many states." In my judgment it is just as important for the National Government to protect the natural industry which has its life and being as a food product in and under the waters of this country as it is to enlarge and protect the waterways for the carrying away from and bringing to us the great commerce of the world. I believe it more important, because the products of the water provided food to man long before he thought of the creation of great fortunes by the use of water courses for commercial purposes.

I am a state's rights man, and am jealous of any action of the National Government which would deprive the state of a single right. But when I consider that the great bodies of water which produce natural food run through and by different states; when I consider that petty political influences, jealousies, and other equally silly reasons prevent a state from protecting from extermination a natural food product, I am convinced that the only solution of this question is in rational control of the fish by the Federal Government. I hope this congress will put itself on record to that end, for I believe that not until this is done and the Federal Government legislates for fish protection and supplies its powerful backing to the enforcement of such laws will the question of fish protection be solved.

NATIONAL ASPECTS OF ANGLING AND THE PROTECTION OF GAME FISHES

By H. Wheeler Perce

President National Association of Scientific Angling Clubs

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

NATIONAL ASPECTS OF ANGLING AND THE PROTECTION OF GAME FISHES.

By H. WHEELER PERCE,
President National Association of Scientific Angling Clubs.

In view of the many mightier subjects confronting this distinguished body, I feel constrained to be brief, particularly as I know you will accord the official delegates from this association an opportunity to voice the sentiments for which we stand. My love of the sport of angling, however, and my regard for my fellow-anglers, are so great that I can not refrain from presenting a few of my ideas, Utopian though they may be, regarding the situation as I see it, and commenting also upon those points, reforms, and conditions which I know my fellows advocate. We are indeed gratified that angling and sport fishing constitute a portion of your programme, and I think it safe to say that many thousands of people will be more or less affected by what you may do in this one branch of your deliberations.

Whatever the arguments pro and con may be concerning angling as a sport, the fact remains that it is contributory to the happiness and health of very many of our citizens. The number of people who engage in the sport either crudely or in the most scientific manner, ranging from the boy with the cotton string and penny hook to the deft master of the delicate bamboo weapon, is simply astounding, and can not at present be estimated. But their name is legion.

Thousands upon thousands of dollars are invested in enterprises devoted solely to supplying these people with the paraphernalia appertaining to the sport. From one end to the other of this broad land of ours, wherever the waters attract, will be found buildings ranging from the rude slab cabin to the great caravansary, devoted to the needs of angler guests and in numberless instances catering only to this class. These investments aggregate millions of dollars and with their necesssary operatives constitute an industry in themselves.

Land and water transportation companies reach out for the business the angler's patronage means to them, in many instances even going so far as to expend funds in stocking the waters along their lines in order that these waters

may remain prolific and an allurement to the lover of fishing. Guides and boatmen by the hundreds, the owners of vehicles, the builders of boats, the dealers in specially prepared clothing, food, and equipments make up an army in themselves. Laying aside all my natural bias due to the intense interest with which I regard all matters appertaining to angling, frankly, it seems to me that these few enumerated facts are prima facie evidence of the importance attaching to the sport.

These great interests, however, combining both the strictly commercial and the no less important simply recreative, find themselves confronted with conditions that if not bettered will in a few years be no less than appalling from our standpoint. The causes of these conditions are many and varied and the necessary steps looking toward their reformation are fully as numerous.

Ruthless deforestation, that most horrid mark of man's insatiable greed, has contributed to the depletion of our beautiful waters. The inference here is plain that a renewal of the forests would be contributory to a reestablishment of earlier good conditions. Streams in many localities that but little more than a decade ago sheltered the fastidious grayling are now barren, for this beautiful creature must have eternal shade.

Manufactories by the thousand pour their foul refuse into the living streams with which God has blessed this glorious land. As a practical man, with some knowledge of filtration and disposal of refuse matter, I feel warranted in boldly asserting that this type of offense could be remedied in ninety-nine cases out of a hundred without any severe tax on the offender.

Night fishing with jack lights, seining, spearing, dynamiting, and all wastefully destructive methods of capturing game fishes, together with the use of obnoxious, murderous lures, constitute an unending menace to the game fish life of our American waters, both fluvial and lacustrine. The remedy here, as in all cases, is proper laws, but, more important still, their proper enforcement. It may be asserted in generalities that the different state laws now in existence, and all more or less meritorious, fail in results because of their nonenforcement in an efficacious way. In many cases this nonenforcement is not venal because of no available resources from which to raise funds to provide for the maintenance of a proper force of officers. It is gratifying to know that in a few localities wise laws prevail and are properly enforced, and in these few localities results indicate splendidly the value of such conditions.

Another potent cause of the falling off in numbers of our game fishes is their capture during the spawning season. This needs no dissertation, for we all know how prolific fishes are if given a chance to reproduce properly. Here again is a question for the lawmaker.

Not the least cause of trouble arises from that peculiar phenomenon in human nature, the respectable lawbreaker. Honorable men, who would not pick a pocket or cheat in business or lie or break any of the usual laws, in many

instances seem devoid of an appreciation of the law in its relation to game or game fishes. They not only do not seem to think it is wrong to break the law but to imagine it is entirely justifiable, their only concern being to avoid detection and capture. This type of offender usually reforms, particularly if he comes under the educational influences of some friend possessing the true sportsman's instinct, but his activities would be materially lessened and his education in sportsmanship hastened if the laws of the United States hung over him.

Would it not be possible, feasible, and advisable to have a federal law in relation to all of these abuses and concerning the proper protection and conservation of game fish? And would not the lawbreaker under such circumstances face the more serious difficulties always attendant upon federal prosecutions? Would not his respect for the law be greatly enhanced and his fear of the consequences of his ill doing increased? To-day, at the best, the lawbreaker confronts simply a state law enforced by a petty officer more or less subject to influences of an irregular sort and oftentimes in a community not in touch with the spirit of the law. Would not a federal law establishing a latitudinal closed season during the spawning period be of inestimable value? This would permit of the legal and sportsmanlike capture of game fishes immediately after the spawning season and would protect the fishes in those sections where spawning occurs earlier than in others and so on up through the different latitudinal sections from south to north. These divisions could easily be established from our knowledge of the spawning habits of game fishes and naturally apply more to basses than to trout, but in the latter case proper sectional provisions could be made.

Regulations restricting the number and size of game fishes to be taken in a given time in the open season by any one person and governing the type of appliance permitted for their capture—the number and kind of hooks used, etc., cuts an important figure—in the minds of many of us should be very stringent.

The sale of game fishes at any time, except for stocking purposes, should be absolutely prohibited, and in many quarters it is conscientiously believed this is the crux of the situation, and that if such a condition could be brought about the problem of depletion would be almost if not fully solved.

Another serious matter which threatens the welfare of the game fishes of our rivers and lakes is the introduction and rapid increase and spread of coarse types alien to the waters they now infest. Their ready adjustment to the new environment and their destructive habits are too well known to need comment, and their extermination is assuredly expedient, even at the expense of the small commercial value they represent, for this is surely of no moment as against the inestimable value of clear, undefiled streams, well supplied with noble food fishes, the rightful heritage of all the people and for their honest use in an honest way and as originally given by the Giver of all good.

Still another question that appeals to many of us and which could be adjusted through national legislation is nonresident discrimination in the matter of rod or gun license which exists in some of our States and which is unpatriotic and selfish, contrary to the spirit of the Constitution, and repellant to every free-born American who loves his entire country. To the true sportsman there are no divisional lines, and his neighbor from afar is as welcome to fish in his home waters as the citizen of his own county. Would it be asking too much of Congress that a congressional committee on game and game fishes be established? Assuredly it would not be too much to ask that the subject of game and game fishes be incorporated in the work of some existing congressional committee.

I have tried to restrain my enthusiasm and be as brief as possible, while according my subject at least some scant consideration. I have viewed the situation only as it exists in the United States. Surely our good friends from the older countries can give us great help and advise us wisely from their store of knowledge acquired through their longer experience.

SPORT FISHING IN CALIFORNIA AND FLORIDA

By Charles F. Holder

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

SPORT FISHING IN CALIFORNIA AND FLORIDA.

By CHARLES F. HOLDER.

It is not generally appreciated by the public that "sport" has economic value. By the unthinking it is not taken into account in the evolution of a country, being considered a waste of time, a mere amusement. Yet sport brings four or five million dollars into the state of Maine every year, and sport, particularly angling, brings quite as large a sum annually to California.

Over 170,000 people visit the Channel Islands of California every year. They make the attractive pilgrimage mainly to the shrine of Walton, for here, from Coronado to Santa Barbara and particularly at Santa Catalina and San Clemente (a United States Government island), is to be found the finest sea angling in the world.

Rod and reel fishing has been reduced to an exact science here, and this has been accomplished through the Tuna Club, an organization which includes in its membership most of the notable sportsmen of the country—as Ex-President Roosevelt, Henry Van Dyke, Gifford Pinchot, Charles Halleck, Casper Whitney, the late Ex-President Grover Cleveland, and many more. This club has introduced light-tackle fishing as a sportsmanlike movement, also to prevent the undue slaughter of fish, and thus accomplishes a most valuable work in conserving all the resources of the ocean. By this club's efforts business in fishing tackle has been enhanced a thousand times; hundreds of people find direct employment as boatsmen and employees in allied interests; large sums are brought into the state from numerous parts of this country and Europe and sport, or one feature of it, has been elevated and dignified as a state and national asset of unquestionable importance. In the present paper some of the most important of the great game fishes of southern California and Florida are described.

AT SANTA CATALINA ISLAND.

The black sea bass of Santa Catalina is a game and food fish which attains a weight of 800 pounds, averaging 250 pounds, and is very common in this locality, living in and about the kelp or nereocystean forests that surround the island. It appears in May in schools of six or seven, breaks up and is ready to

spawn in August. Professional fishermen take it for the market with "cod" lines and albacore bait, but the anglers of the Tuna Club use 24-ounce and 9-ounce rods with a reel that will hold 1,000 feet of a 9-thread Cuttyhunk line made for the purpose. The line is made in a building 700 feet long and is tested to pull a dead weight of 2 pounds to the thread. With this tackle the anglers go to the grounds in launches especially designed for the purpose, 18 or 20 feet long with 8 or 10 horsepower gasoline engines. In the stern are two comfortable chair seats, one fishing to the right, the other to the left. On reaching the ground the boatman tosses over the anchor, fixing a float to it that he can cast off. The angler straps on a belt with a socket for the butt of his rod, baits the number 7/0 O'Shaughnessy hook with half a barracuda, or a 6-pound whitefish, or a piece of albacore, and tosses it over in 40 feet of water. He may have to wait for a strike or he may get one immediately. The strike is delicate, and when it comes the angler pays out 10 or 20 feet of line, then strikes. If he hooks the fish there is a heavy rush and the boatman casts off the anchor (fig. 1, pl. 1) and follows the fish, or keeps the angler stern to it until he brings it to gaff, which may take an hour or five, according to the fish. The gaffer, if the fish is large, tows it in, if small (150 pounds), he takes it on deck (fig. 2, pl. 1) and goes into port (fig. 3, pl. II), where scores of people hurry down to the dock to see the fish weighed.

The tuna of the Pacific, or horse mackerel, or tunny, is taken in the Mediterranean in great nets, miles long, being driven in, and the nets at Sicily are of great value. In America the tuna, of three kinds, is taken as sport and is also used as a food fish. The leaping tuna comes into Catalina in June and remains until January. It is considered the greatest of all game fishes. The tackle is a 24-ounce rod, a 24-thread Cuttyhunk or other good line, and a large reel of Vom Hofe make. The angler does not wear a belt, but has a socket on the seat for the butt of the rod. (Fig. 5, pl. III.) Flying fish is the bait, which is trolled about 100 feet behind the boat. Anglers play the fish and troll for it. They also approach the schools and cast the heavy bait in front of them. The fish average 170 pounds (fig. 6, pl. III) and the record is 251 pounds with the tackle described. Market fishermen fish with heavy lines from sail boats, but the fish is so powerful that few care to do it. The fish is a famous leaper before it is hooked and when feeding, and preys almost exclusively on flying fish and squid. It is found in all temperate and semitropic seas, and often weighs 1,500 pounds. This tuna is fished for a quarter of a mile offshore on about 4 miles of coast at Santa Catalina and has not been taken with a rod in any other locality. It has been known to tow a boat for 30 miles.

The albacore, long-finned tuna, or alalonga, ranges up to 100 pounds and is found in many localities off Santa Catalina Island. It lives in deep water but near the surface. It looks something like the blue tuna but has very long

pectoral fins. It is followed by anglers and taken with either a 6-ounce rod with 6 or 3 thread line (this for experts) or a 9-ounce rod with 9-thread line. The bait is sardine and the fish are so ravenous that they will at times snatch a sardine from one's hand, or the game can be hooked at the side of the boat when the school is located, during which operation the bait is towed behind the boat.

The yellow-finned tuna, which is a beautiful fish and attains a weight of 100 pounds, averaging 45, is common in Japan and at Honolulu, and appears at Santa Catalina in September. The largest specimens are taken with rod and reel for market and sport. It resembles the leaping tuna but has a short fin, with the finlets a vivid lemon-yellow. (Fig. 11, pl. VI.) It will tow a boat 2 or 3 miles.

The bonito or skip jack is another of the beautiful fishes of California and other seas. It is taken with a 6-ounce rod, no. 6 line, small hook (7/0), and sardine bait. The hook in baiting is thrust through the mouth, out and into the side, the mouth of the fish closed by being wound by wire. The bonito attains a weight of 20 pounds and is a vigorous fighter, having a peculiar wriggling motion, and playing on the surface entirely. The angler follows it in launches.

The oceanic bonito comes in early spring. It attains a weight of 25 pounds, is beautifully barred and silvery. It is taken on a 6-ounce rod, and a line that will stand a dead strain of 12 pounds; sardine bait, a long piano wire leader, 6/0 hook and light sinker. (Fig. 4, pl. II.) The boat proceeds at a rate of 3 or 4 miles an hour trolling 80 feet of line, and the fish is gaffed when brought in.

The white sea bass is a food and game fish of California attaining a weight of 100 pounds. It is taken by market men in nets at Monterey, but at Catalina is a great game fish (fig. 7), and to encourage anglers to use light rods valuable prizes are offered for the big specimens. The club record is 60 pounds. The fish is taken with a 9-ounce rod, 9-thread line, by trolling with a sardine on a 7/0 hook and 6-foot piano wire leader. It makes a fine play, and requires skill to land. The white sea bass appears in May and disappears in August, and except in Monterey may be considered an offshore fish, being taken in greatest numbers at the Channel Islands of California. In the Gulf of California it attains a weight of 150 pounds, and is often taken in the surf on the east coast of the Gulf, north of Tiburon. It prefers flying-fish bait, but live smelt or sardine is good; also a Wilson spoon in trolling. The live bait is used in still-fishing, the plan being to drop an empty hook into a school of sardines and snag a fish, which, if there is a white sea bass around, will be taken at once. Remarkable catches are made in Avalon Bay, where the fish all weigh over 50 pounds. There is another species of the fish, averaging 15 pounds, called "sea trout," which is taken in the same way. Both species are related to the eastern weakfish, or squeteague.

The yellowtail of the Pacific coast is not the yellowtail of Florida, but is closely related to the amberfish, or amber jack, of the latter region. It is the common fish of southern California, where it attains weight of 100 pounds. The rod record is 60 pounds. It is a beautiful fish, blue, silver, with yellow median line fins and finlets, and all in all the hardest fighting fish known. It is taken by hand lines for the market in deep water near shore or at the surface. In the early season it runs in schools, but breaks up and solitary fish are often seen. If the winter in southern California is warm and dry, the yellowtail is taken every month in the year, but if cold the fish goes to offshore banks or down into very deep water, where its food supply also doubtless winters. It is taken from rowboats (fig. 8, pl. IV) or launches, with rods 6 or 9 ounce split bamboo, 6 feet or over in length; medium-sized reel, 9-thread line, with 6-foot leader of wire, 7/0 hook, and large flying-fish or small sardine bait (large fish take the former). It can be taken by still fishing or trolling, is a wharf fish as well, and is also taken under kelp patches miles out to sea. It is the fish of the people in California, worth thousands to the state as a game fish (fig. 11, pl. VI), and equally valuable as a food supply to the masses. It spawns in the summer.

The barracuda, found in schools in California in summer, is taken in gill nets, also on light tackle rods. It is a good food but poor game fish. In August the schools break up and individual fish are seen. The barracuda takes sardine or smelt bait.

The ocean sunfish (fig. 9, pl. V) taken for sport, attains a weight of 2,200 pounds in California, and is found all over the world in temperate waters. It takes bait but rarely. The author hooked one August 26, 1908, and landed it by rushing at it in a launch, gaffing it quickly, and holding on to it, despite its rushes. It weighed half a ton doubtless, and was 10 feet high. This fish is very common in southern California waters. On pleasant days it can be seen jumping, and the pursuit of it constitutes sport for those who like lusty pastimes at sea. It is generally taken with a spear, but to hook it and rush the launch in and gaff it before it goes down is a game that has no little excitement. I have taken large specimens off the Atlantic coast in this way and once off the Florida coast. No more extraordinary creature can be imagined than this colossus with no appreciable tail, a fish all head with its two huge fins pointing up and down, dotted with waving parasites, splashed and spotted with membranifera, sailing along in the deep blue sea. The small ones go in schools. The skin is used as sandpaper, the muscle as rubber for balls.

The California flying fish is taken as food in seven ways: One by setting a gill net at the surface; the fish is so stupid that the moment it touches the net it stops and turns over and is easily caught. The sportsmanlike way to take it is to shoot it with a shotgun. This I have accomplished by seating myself

in the bow of a fast launch, and as the flying fish rises on either hand shooting it either to the right or left. A good dog might be trained to spring and retrieve flying fish, though the ordinary plan is to run alongside and take them with a scoop net. The fish are in demand as food but are more valuable as bait for tuna or yellow-tail fishing, bringing $1 a dozen in the season from May to October. Numbers of people have been struck by them. One hit the writer in the neck and nearly knocked him overboard. The fish does not fly but soars, holding its wings rigid and covering a distance of a quarter of a mile.

At Santa Catalina the sheepshead is a good game fish. It is taken either from the rocks or from the boats near shore. The tackle used is an 8 or 9 ounce rod, a 6-thread line, and abalone or crayfish bait. A sinker should be used, as the fish is found on or near the bottom.

A good hard-fighting fish caught here is the leaping shark, taken from the beach of Catalina Harbor with a light rod. Like the tarpon, the fish will leap as soon as hooked, and for a while makes a very fair fight.

SALMON AND TROUT IN CALIFORNIA.

One of the finest game fishes in America is the salmon, taken with rod and reel in the streams and rivers of Canada. On the Pacific coast the salmon congregate in Monterey Bay before entering the rivers. At Monterey, Santa Cruz, and Capitola they are fished for from boats, the professional fishermen with big boats, using hand lines and heavy sinkers, in water 40 or 50 feet deep, with sardine bait, but the sportsmen using a rod weighing 9 ounces, with a 9-thread line and 7/0 hook baited with smelt, anchovy, or sardine. A sinker is needed, and an ingenious device is used to release the sinker and enable the man to play the fish. The line near the hook is connected by a thread on which is run a pipe sinker of lead. When the fish strikes the thread breaks, releasing the line, and the angler plays the salmon, which comes to the surface and leaps, making a fine play. Large catches are made (fig. 10, pl. v).

California abounds in trout, and the methods of angling are the same as in the East, 2, 3, 4, 6, and 8 ounce split bamboos being the rods most in vogue, with "E" silk lines and 6-foot leaders and one fly, of a kind depending upon the locality. At Klamath Lake, where the giant rainbows are found, the "March Brown" fly is the best, the fish making a fine play, leaping from the water. In Feather River, Plumas County, Cal., they are taken in the same way. The river is swift, and the fly fishing excellent, big deep pools being found everywhere here. A cork fly or "grasshopper" is very killing.

In the Sacramento, also in the Kern and other streams, the fishing is excellent with the fly. The black bass has been introduced, also the striped bass in the waters about San Francisco Bay.

ON FLORIDA COASTS.

Florida is famous for its game fishes, and, except the tarpon, they are also food fishes. The tarpon is the great game fish of the world. In some localities it is taken with hand lines, but the method in vogue among sportsmen is to take it with a 9-ounce rod, 9-thread line, and 10/0 hook with mullet bait. The boat (launch or rowboat) trolls slowly, with 30 or 40 feet of line out, and at the strike the fish goes into the air in repeated leaps, giving a fine play. One hundred miles south of Galveston, on the Gulf, is the Aransas Pass Tarpon Club, a well-known organization, and when brought to the boat here the fish is towed inshore, measured, and released. Here, as in Florida as well, in shallow water, the big jewfish also is taken, with 16-ounce rods, 24-thread line, large hook, and wire leader. This fish attains a weight of 400 or 500 pounds, is sluggish, and found in holes.

One of the interesting food and game fishes is the hogfish, beautiful in rich red tints and with waving plume-like fins. A hand line is used for its capture, the sinker on the bottom and large hook 2 feet above, so that it will swing clear of the coral. This is lowered in water from 30 to 60 feet deep in the coral, and catches of 15 pounds are taken.

In shallow waters the most beautiful of all the Florida fishes is the gray snapper. It is caught by the professionals with hand lines, as above, with crawfish or conch bait; but an 8-ounce bass rod is to the sportsman's taste, with a fine no. 6 line, and a bunch of small sardines for bait. The fish resembles a black bass, and plays like one, but does not jump. There are a number of snappers, all caught the same way.

Related to the snappers is the beautiful little yellowtail, with yellow stripes and fins. A 6-ounce rod, a no. 6 line, and 4-inch hook baited with crawfish is the lure, and on the shallow reef among the gorgonians or sea fans it is found in great numbers, affording good sport, besides being an excellent pan fish. This fish is quite different from the big yellowtail of the California coast.

Along the mainland is found the sea trout or squeteague, a fine game fish, taken with the same tackle. No fish makes a better fight. The bait for it may be sardine, smelt, or crab.

Common wharf fishes of Florida are the porgies, which throng some localities in myriads. They are good pan fish.

Notable food fishes here are the groupers. The red grouper is the most valuable, and specimens weighing 50 pounds have been taken. It is a deep-water fish, caught on a hand line, with conch bait or anything at hand. Other groupers are taken on the same tackle (hook above the sinker).

The ladyfish is a splendid game fish, ranging up to 6 and 7 pounds, long, slender, and silvery. A 6 or 8 ounce rod, 6-thread line, crab or fish bait is the

tackle. Upon being hooked the fish leaps into the air and literally dances over the water on its tail. The bonyfish is very similar in its action.

The common pan fish on the reef is the grunt, found literally in thousands. It is rather a poor game fish, but makes a fairly good play on a 6-ounce trout rod. Any bait is acceptable to the grunt, but especially crayfish. As its name suggests, it grunts when taken out of the water.

On the reefs are a number of fishes known as "jacks," ranging up to 16 pounds and over. They run in schools and chase sardines, and can be caught with this bait. Few fish make a more game play, dashing through the water and breaking the line of the novice. They are mostly caught on the hand line trolling, but the true way to take them is with a 6-ounce rod, 6 feet long, 6 line, 7/0 hook, and sardine bait. This tackle is small and delicate for the fish, but can take them in the hands of a skillful angler.

At Palm Beach, the amberfish is taken with a 10-ounce rod, 21-thread line, and sardine bait. Boats are rowed out beyond the surf and still fishing is the method. This fish is allied to the California yellowtail, and puts up a splendid fight. The angler wears a belt with a leather socket in which he secures a certain leverage, and often plays the fish an hour or more before he brings it to gaff. (Fig. 12, pl. VI.) Amber jacks of 50 or 60 pounds are taken in this way.

The northern bluefish is a splendid catch on a 9-ounce rod, 9-thread line. So are the channel bass, drumfish, and striped bass. All should be taken with this tackle

FIG. 1.—The strike.

FIG. 2.—Gaffing a 240-pound capture.

ANGLING FOR BLACK SEA BASS, SANTA CATALINA ISLAND.

Fig. 4.—The record bonito, Tuna Club 1908, rod and reel. This fish, which weighed 22 pounds, fought for more than an hour. Note angler's belt with socket for rod butt.

Fig. 3.—Weighing a big sea bass.

Fig. 6.—Leaping tuna caught with rod and reel at Santa Catalina.

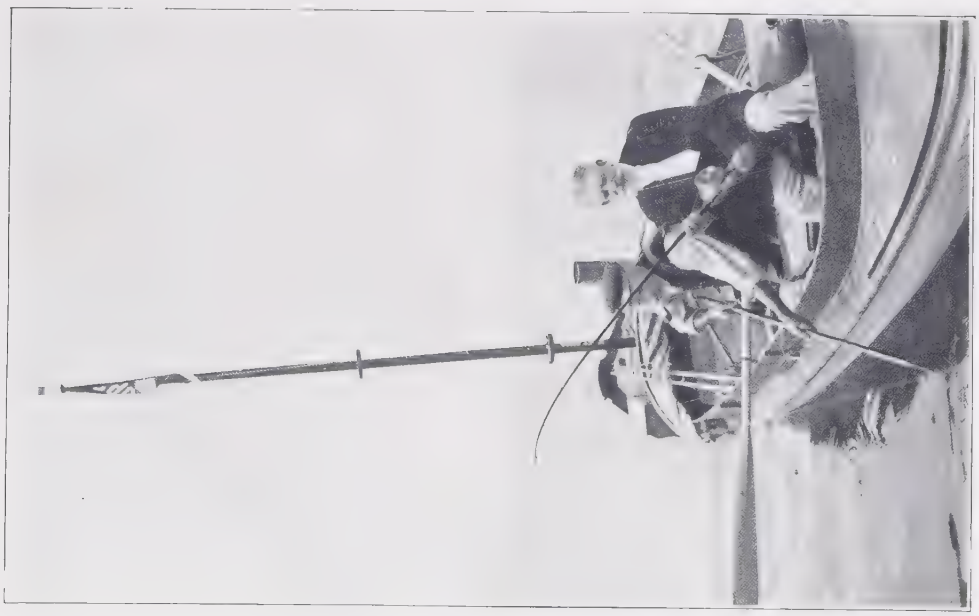

Fig. 5.—Angling for tuna, Santa Catalina. Typical launch and equipment.

Fig. 7.--A day's sport at Santa Catalina Island with white sea bass.

Fig. 8.—The yellowtail anglers of Avalon Bay, California (Santa Catalina Island); 200 to 300 boats often seen, all fishing with rod and reel.

Fig. 9.—The record sunfish, Santa Catalina Island, too heavy to weigh; estimated at 2,850 pounds.

Fig. 10.—A salmon (rod and reel) catch, Del Monte, California

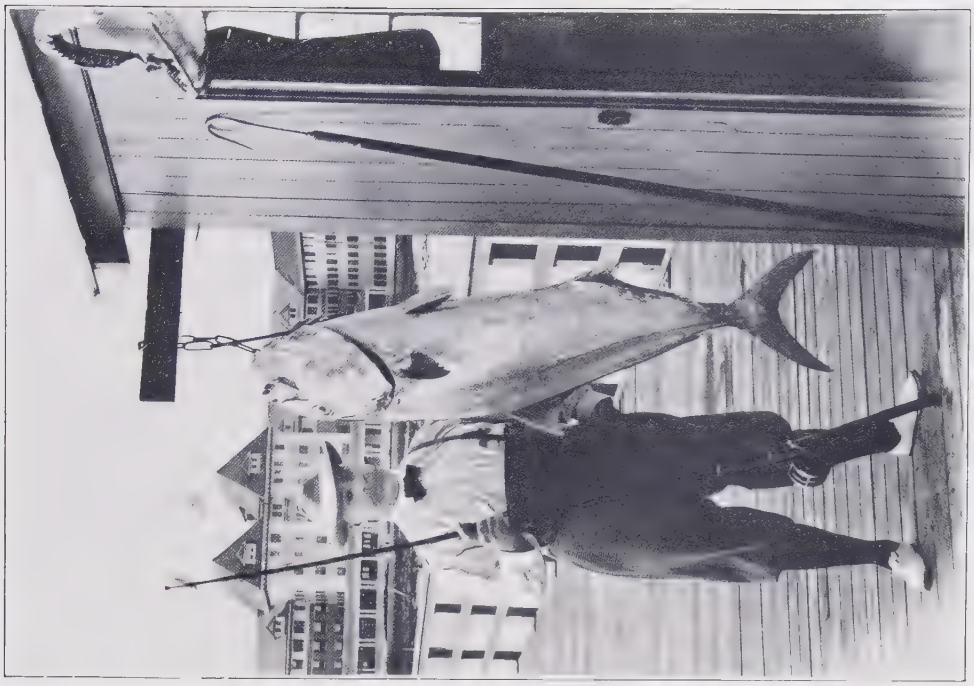

Fig. 12.—Amber jack, caught at Palm Beach, Florida.

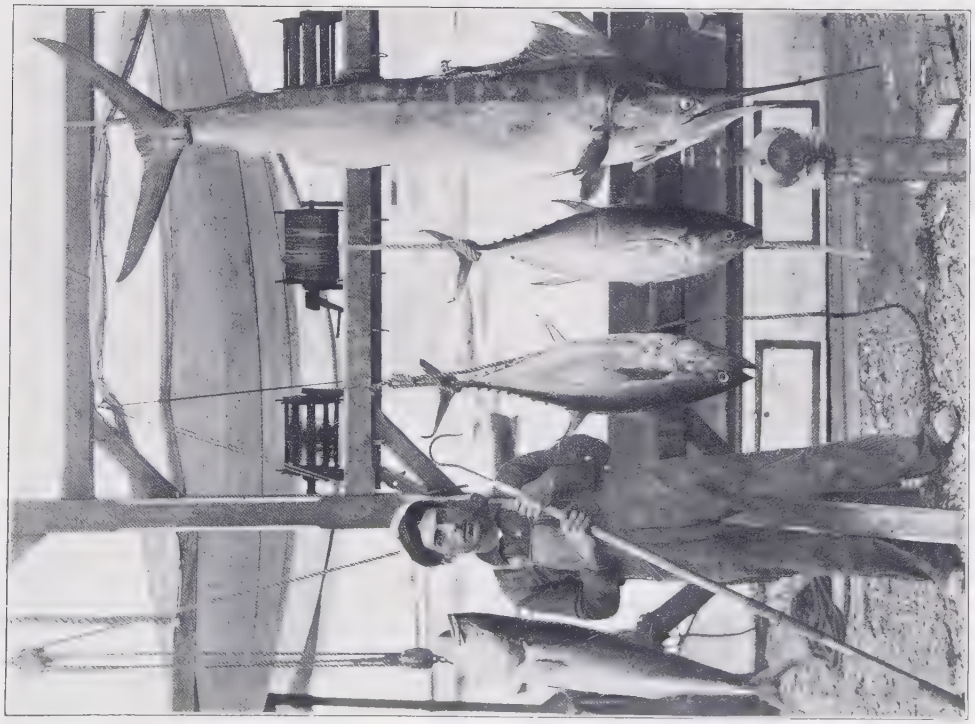

Fig. 11.—Swordfish (*Tetrapturus*), yellow-fin tuna, and yellowtail, caught with rod and reel at Santa Catalina Island.

LOBSTERS AND THE LOBSTER PROBLEM IN MASSACHUSETTS

By George W. Field

Chairman Massachusetts Board of Fisheries and Game

WITH DISCUSSION

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

LOBSTERS AND THE LOBSTER PROBLEM IN MASSACHUSETTS.

By GEORGE W. FIELD,
Chairman Massachusetts Board of Fisheries and Game.

Mr. PRESIDENT AND GENTLEMEN OF THE CONGRESS: In 1873 it was found necessary in the state of Massachusetts to make some regulations restricting the catching of lobsters. At that time the first law was made, and, as subsequent experience has shown, it proved to be a biological blunder and a thoroughly illogical procedure. They started out with the assumption that if the lobster had an opportunity to lay one litter of eggs this would be sufficient to insure a supply for increasing demand. It was not long after that it was found the lobster supply in the neighborhood of the great cities—particularly New York and Boston, the great markets—was decreasing very rapidly; and that decrease has continued until now the supply in Massachusetts has diminished over 66 per cent in the neighborhood of Boston in three years. If we examine the evidence, there is absolutely no question that this decline in the lobster catch is an actual and not a theoretical one.

It is evident, first, from the fact that it is necessary for the fisherman to tend, not 10, 20, 30, or 50 traps, as he formerly did, but he must now have 100 or 200, in order to get the same number of lobsters. The number of men in the business has increased very largely. They are obliged to cover a larger area in order to get a proper supply. But most prominent of all is the fact that the number of egg-bearing lobsters has diminished in proportion to the total number of lobsters in the water. In 1890 statistical evidence indicated that there was about 1 egg-bearing lobster to every 20 which were not carrying eggs; whereas in 1907 it was found that this ratio had declined so that there was only about 1 egg-bearing lobster to every 101, showing that the egg-bearing lobsters were only about one-fifth as numerous as they formerly were. This has come about from the fact that we have been taking from the larger lobsters, the adult lobsters, each year. We have, in other words, been cutting off the big timber, which was producing the new material, the seed, and in that way we have diminished the reproductive capacity of the race. During the past four years, in my personal experience, we made measurements of about 3,500 or 4,000 egg-bearing lobsters each year. These measurements have been carefully made, and the lobsters

divided into two classes—those above 12 inches and those below. I have some figures here indicating the decline in the size of the egg-bearing lobsters, and with that comes the very important fact that there has been a corresponding decrease in the number of eggs laid. In 1905 we found there were 185 lobsters over 12 inches long to every 100 under 12. In 1906 this number had declined to 133 above 12 inches to every 100 under 12; in 1907 came the very astonishing reduction of 39 over 12 inches to every 100 under 12; in 1908 there was somewhat of a rise, and the number this year was 110 over 12 to every 100 under 12. Taking the average of the first two years, we find that the average for 1905–6 was 159 lobsters over 12 to every 100 under 12; and in 1907–8 this had declined to 75 egg-bearing lobsters over 12 to every 100 under 12.

This seems to me to indicate that we are going at the matter in the wrong manner; that the present laws are entirely illogical, and that we are decreasing annually the reproductive capacity of the race by destroying the best of the lobsters of reproductive age each year. To meet this situation we are suggesting to the legislature of Massachusetts that just as it was responsible for this original law, so it should pass another law to remedy the situation. It should consider the fact that it is necessary to have a law which will meet the conditions by protecting not alone the young lobster before it reaches an age of economic importance, but also the adult lobster, which produces the eggs necessary for propagation.

We need to support the work of the Bureau of Fisheries, which for many years has been propagating the lobster artificially; the admirable work of the Rhode Island commission, and the work of the Maine commission, all of which has been on the line of saving the eggs which have been laid. There should be some provision made for increasing the number of eggs which are annually produced, and it seems that this could best be done by protecting the adults, say above 11 or 12 inches long, in such a way that their capture may be entirely prevented. We are therefore suggesting that the traps be made with a ring 3¼ or 3½ inches in diameter, a size so small that the large lobsters of reproductive age can not enter. And thus we will have a law that will enforce itself automatically. The traps are to be officially inspected and sealed, and these traps must conform to the specifications, and in that way the law could be readily and economically enforced.

DISCUSSION.

The PRESIDENT. Is there approval or objection to the measure that has been suggested?

Mr. HENRY T. ROOT (Rhode Island). I was going to say, Mr. President, I hoped that the president would answer that question. I will say, however, while I am on my feet, that in Rhode Island the increase of lobsters has been amazing within the last three years. We lay it wholly to protection. We are enforcing the laws thoroughly. We put men in prison; we fine them hundreds of dollars; and we have got them now so that the fishermen are with us. Our laws are enforced, and the small lobsters are not put on the market. We save the egg lobsters and get more than we want by paying for them.

When we first started in the lobster business it was difficult for us to get 80 to 100 egg lobsters. This year we had no trouble in getting several thousand; last year we got more than we could begin to handle, simply paying the fishermen a little more than market price for egg lobsters. We save them in that way; we strip them, put them back in the water, and they go on; and in two years more, if the fishermen do not get them, we will have more egg lobsters—the same ones.

This method of Doctor Field's sounds very plausible, but with all his arguments the Rhode Island commission has not been able to give it their indorsement. I think thorough protection will increase lobster production, as it has in our waters of Narragansett Bay, where we got last year, in that little bay, over 1,000,000 pounds of lobsters. This year we should get many more; and the fishermen are getting rich in the short time they have to catch them. One man on Block Island made alone $1,300 catching lobsters in the open season. We feel that we are doing great work there. I wish that Doctor Mead was here. And, furthermore, I would like to say, while I am on my feet, the whole inception of our industry was inaugurated by President Bumpus.

The PRESIDENT. The figures that Mr. Root has mentioned are really very striking, both to us of this country and to our foreign friends; and when I tell the visiting delegates that this summer I have been paying 25 cents per pound for lobsters, and state the total amount of lobster meat taken in the lower part of Narragansett Bay, which is a small bay (the lobsters do not get very far up the bay of our smallest state), you have a sum of money coming in to the poor fishermen there that is really very considerable; those figures once more, Mr. Root? It was how many?

Mr. ROOT. One million pounds last year. This year it will be a good deal less.

The PRESIDENT. It was 1,000,000 pounds. This makes $250,000 that has come into the pockets of fishermen. There are only a few lobster fishermen in Narragansett Bay.

If you will permit the chair to comment a little further, I would say that I believe that the large catch of lobsters in Narragansett Bay at the present time is the direct result of the efforts of Doctor Mead and his associates on the Rhode Island commission in their methods of hatching the lobster during the first few stages of its development. You all know how the young lobster first hatches from the egg and swims upon the surface, a perfectly helpless, pelagic animal. After it has reached the stage of its fourth moult it is, psychologically, itself; it is no longer timid, but it becomes pugnacious. It is no longer a helpless and free-swimming animal. It settles to the bottom, and it is pretty well able to look out for itself. Now, what the Rhode Island commission has attempted is to keep the lobsters confined until the young lobsters have

developed sufficiently to reach that stage when they are able to look out for themselves. It is practically the same thing that the men interested in trout have been doing for the trout. They have kept the trout until they reached the fingerling stage, and the Rhode Island commission has been keeping the lobsters until they have reached the self-help stage. Of course a part of the itinerary in New England is a visit to the station at Wickford, where this work has been going on. And I might further add that I believe what I say in regard to the work of the commission there will be subscribed to by every practical fisherman in the state of Rhode Island, i. e., that the commission is working in perfect sympathy with the local fishermen.

The paper is now open to discussion. I am sorry I have taken so much of the time myself.

Mr. W. H. BOARDMAN (Rhode Island). Mr. President, I wish to corroborate Mr. Root's statement, and refer to something he did not mention—a fact which has been brought to my attention especially, because I went down to visit the Block Island lobster fisheries.

That year, or previous to two years ago, there was no lobster fishing there at all. The fishermen had gone out of business entirely. Of course at one time, years ago, the little ground surrounding the island was good ground for fishing; but, as I understand it, for the last six or seven years there have been absolutely no pots set around Block Island, because it did not pay. Last year two or three fishermen ventured to set a few traps, and they were successful to so great an extent that in this year, in July—no, in the early part of August—when I went down to visit those fisheries, I found 80 fishermen had engaged in the business, with 3,000 traps. In a visit of two or three days' duration I saw quite a number of lobster fishermen come in with their daily catch, and it was simply enormous. Each daily catch represented a large profit. In some cases it would take fifteen minutes to dip it with a bucket from the car to the vehicle on the shore with which they went to the markets. They claim, without exception, and I have no doubt they are uniformly enforcing the law, that it is all due to the Rhode Island commission's preventing the catching of less than 9-inch lobsters and the fishermen's sending what egg-bearing lobsters they have to our commission at Wickford, to be hatched and raised, as you say, to the fourth stage.

The PRESIDENT. This island is a relatively small island, some 10 square miles in extent, in the mouth of Narragansett Bay—an island of, say, 5 miles in extreme length and 3 miles in width.

I am inclined to dwell on this a moment, because the efforts to stimulate and revive a waning industry are so often fruitless that when activities result in apparently pronounced success it seems to me well for us to accentuate that.

Are there other comments to be made upon this matter of the lobster fisheries? I wish that Professor Prince, if he is here, would speak. The work in this line I know has been carried on in thorough sympathy between the two governments. Are there others who will speak? If not, the next paper will be called for.

Mr. DONAHUE (State Fish Commissioner of Maine). Mr. President——

The PRESIDENT. Will you be good enough to come to the platform? Permit me to say to the foreign delegates that the lobster industry of the Maine coast is one of the most important in the United States.

Mr. DONAHUE. During the remarks with reference to the lobster made by the gentleman who preceded me, it occurred to me that it might be of interest to some who are not as familiar with it as we are to know just what the conditions are as we find them in Maine, where we produce more lobsters than all the rest of the country combined and therefore think we ought to know something about the subject.

We produced last year 8,000,000 pounds of large lobsters. We do not make our measurement as small as the other states. Massachusetts and Rhode Island have a 9-inch law; so do the provinces. Our lobster, to be a legal lobster under the laws, must be approximately 10½ inches long. We changed our method of measuring at the last legislative session, which was a year ago last winter, on account of the curious way

the fishermen had of doing it. A lobster must as the law required measure 10½ inches from the end of the nose to the rear end of the tail shell. Now a lobster is in two sections, practically, so that he can be pulled out or shoved in; and if a fisherman wanted to make a lobster "go" that was a little short, he would give it a little wrench or pull and it would stay out. Then he would say to the buyer, "Measure him again;" and the lobster would be found to be all right. That was a very bad practice, and by it we have lost a great many lobsters. The fellow that caught the lobster might be able to sell it, but in a day or so the man who bought it would have a dead lobster instead of a live one. So we adopted a new law. A lobster now must be measured from the end of the nose to the rear end of the body shell. This is one solid shell, and there is no way to pull it up or stretch it in any way, so that 4¾ inches is the measure now, which is approximately the same 10½ inches, but measured in a different way.

Last year, as I say, we caught of that size of lobsters between 8,000,000 and 9,000,000 pounds; and the value of them, as received by the fishermen, who are the first hands, was a little less than $2,000,000.

We have a method of propagating in Maine which is a little different from that in Massachusetts, inasmuch as we buy the seed-bearing lobsters, or egg-bearing, as we call it, from the fishermen and pay 25 per cent more for them than the fishermen can get from the market man for the regular legal lobster. We do that to make it an object for the men to save every one of those seed-bearing lobsters, as we do not want to lose a single one.

The lobster is very prolific, producing from 25,000 to 80,000 seeds at a batch. They are great breeders. If they had not been, our lobsters would have been exterminated long ago.

By the way, I want to say that some lobster fishermen do not think it is a good plan to have these fish hatched artificially. They believe the best way is to throw them over into the natural element and let them do their own hatching. If the fisherman objects to our taking them, we say, "We will buy the lobster; and you may throw it overboard in the ocean, and if you catch that lobster to-morrow we will buy it again." But in order to find out how much we were getting "stuck" on that proposition, we took a small punch and punched the thin part of the tail. This does not hurt the lobster. We mark it, and in that way we keep tab on how many times we buy the same lobster in the same year. In one case we rebought a lobster four times, but very seldom do we buy one the second time.

We take those that the fishermen do not object to our carrying to the hatchery. We have a hatchery in the state, owned by the United States Government, at Boothbay Harbor, and they hatch all the lobsters that we can get for them. The State pays us the price that we pay for the lobsters, or the market price of the lobsters. Those lobsters are held in pounds throughout the winter and hatched the following spring, and last year (1907) the hatchery at Boothbay Harbor hatched and liberated on the coast of Maine approximately 140,000,000 of those small lobsters. They are taken out after they are able to swim around pretty well and take fairly good care of themselves and liberated in the coves, up in the mouths of the rivers, where the water is not too fresh, and some out in the ocean. It is more or less a question as to the best way to propagate the lobster, and how to get the best results. After the little fellows are once liberated, why, of course, we do not know any more about them, excepting the results we get the next season or two seasons after in fishing. We have been following that plan now for a number of years—it has been ten years—and our fishing last year showed a marked increase; the year before a slight increase. For this year the statistics are not entirely made up, yet as far as we have gone it appears that we are going to get a very fair increase in the catch of lobsters. The 9-inch law which is in force in Massachusetts and Rhode Island and the Provinces is more or less trouble among our fishermen, from the fact that a fisherman is more or less greedy; when he gets something that he has picked up out of the water he is apt to want to sell it; and we have enforced the law by making it a pen-

alty—a fine of $1—for each lobster found in any man's possession, whether he caught it or whether he bought it, under approximately 10½ inches in length.

That has been the system for a number of years. Two years ago, when I took charge of this department, I was very familiar with the lobster men and their habits, having lived among them for a number of years; and I adopted a different method of enforcement. While I enforce the same penalties and in some cases have to use the same methods, I commenced, instead of using legal suasion on the fishermen, using moral suasion, and have at the present time educated in the neighborhood of 2,000 of them (there are only about 3,000 that fish for lobsters) up to the idea that it is to their disadvantage to sell a lobster before he is approximately 10½ inches in length. So that at the present time there are nearly 2,000 lobster fishermen that are helping the wardens to enforce the law. Without moral suasion, as one of the wardens said to me, "It would take one warden to every fisherman, and then you could not enforce the law," which is true.

The lobsters of the state of Maine are unquestionably on the increase, and we are satisfied in the state that the method we have adopted there is the best method. The idea of selling the small lobster and preserving the big ones is thought the best way by some. As a fair illustration of that I would like to ask any of you gentlemen from the West, where you raise beef, what would you think of a man out there in the beef business who sold all of his veals? Where would he get any beef to sell later? Would not that be practically where we would be if we sold our small lobsters and did not save the big ones, the seed lobsters? What would result if we did not let the small ones grow? This method, I hope, will be the one that will be adopted by the other states. We were very sorry that Maine and Massachusetts could not agree upon a uniform law, because Massachusetts is our nearest neighbor and competitor, and we find it more or less difficult to enforce the law with Boston a market for 9-inch lobsters. I hope the time will soon come when we can all have the same law, and I have not a doubt that, if we do, and give the proper protection to the lobster, there will be no question but we will have all the lobsters that this country wants at fair prices. This year Rhode Island has a larger catch than for a number of years; in fact, it has been a long time since Rhode Island produced many lobsters, and the way it looks now lobsters ought to be sold at lower prices. They have been too high, and it is no wonder that the public found fault with the price. But with the proper protection of the seed and by giving the little ones a chance to grow there is no question in my mind but what we will all have lobsters at fair prices.

Mr. FRYER. There is one small point which has not been touched upon, and that is the question of what I may call the "average minimum size" at which lobsters are found to be egg bearing. The term "egg bearing" I assume is used in the sense of carrying the eggs externally. We have had in England precisely the same trouble that you have had here, accentuated by the fact that where we have tried a law prohibiting the landing of lobsters carrying berries we have found that the fishermen have evaded that law by brushing the eggs off, and in many cases, at certain stages of development, it is very difficult to prove that such a thing has been done and that the eggs have not been shed naturally. In the same direction we have adopted a method of regulation similar to that which you are adopting here, namely, regulation by size; but we are very much in doubt what is the proper size limit to fix. On some parts of our coast we are told that there is a diminutive race of lobsters, and that they never attain what is now the legal minimum size, namely, 8 inches; but within the last two years I have been having some rather extensive observations carried out with regard to the size of lobsters and their condition at the different sizes. One result of that has been certainly in the direction advocated by the last speaker, namely, that the minimum size at which lobsters may be taken needs increasing. We have found—I have not the exact figures in my mind, but I think I am within the limit in saying it—that not one in a thousand female lobsters under 8 inches in length has been found to be carrying eggs externally, which goes to show that our law, fixing the minimum at 8 inches, is per-

fectly inadequate. On certain parts of the coast the size has been increased to 9 inches, and the method that I personally favor, for the moment at any rate, pending more detailed information, is that, in order to meet the prejudices of the fishermen, the minimum size should be gradually increased—if it is only by half an inch per annum—until such a minimum size is fixed as will give at least a fair chance to every lobster—every female lobster—to reproduce once before it is brought to the market.

With respect to the very ingenious suggestion that has been made of a lobster trap which shall let out all the little ones and exclude all the big ones, I would suggest that the practical effect of that, if it works out as the fishermen would like to see it work, would be that you would allow the fishermen to catch all the lobsters at the reproductive size. They would spare them until they reach that size, and in the meantime they would be prevented from catching the larger patriarchs of the ocean. But those patriarchs of the ocean will not live forever, and the time will come when they will die off. You will then have killed off all those of the intermediate, egg-bearing size, and will only have those of the smaller non-egg-bearing size left.

Mr. PAUL NORTH (Ohio). Mr. President, it occurs to me that we of the West, who know nothing about the lobster, except our own peculiar brotherly kind that we have out there, do not help you eastern people to the extent of stopping our states from being the dumping ground of these short lobsters. All we see with us is the short lobster, and it seems to us that if we could pass laws in our state, where we do not raise lobsters, that would prevent the sale of lobsters below the legal limit, we would be assisting very materially in the enforcement of the lobster laws in the states where they raise them. The 6 and 8 inch lobster is common with us, except when they get man size.

The PRESIDENT. The question is raised: At what time does the lobster reach sexual maturity, i. e., the average time, as indicated by its size? I know that the United States Government has made a great many observations on that, and I dare say that Doctor Field has them at his tongue's end. Do you remember, Doctor Field? The smallest lobster to be found with eggs, I believe, was 7¾ inches.

Dr. GEORGE W. FIELD. How many? That was only one individual. Less than 3 per cent of those that have eggs are under 9 inches long, and the great bulk of those we have taken have had an average size of about 11 inches. There is a small number above that. We will say that with a curve the number below 11 inches and the number above 11 inches is about the same; but those above 11 inches will produce at least five times as many eggs as those on the other side—as those between 9 and 11 inches. You doubtless know that the first litter of the lobster is about 5,000 to 10,000 eggs, and then each two years later it doubles—10,000, 20,000, 40,000, 80,000, the largest being 96,000 eggs in a 17-inch lobster.

Now, our contention is that if you make a perpetually closed period on the large lobsters you preserve those large lobsters which produce eggs and have a continual supply of eggs hatching, and have young ones growing up from them; whereas, at present you have a wide-open season, so to speak, on all the lobsters above 9 inches which are exposed to capture. Under the laws proposed it will be legal to take them only when between 9 and 11 inches, and they are protected except during a very small portion of this breeding age, i. e., when below 9 inches.

In regard to the simile of the cattle breeder, it is perhaps not necessary to say that there is no sane cattle breeder who would kill off his very best stock. He would keep the best stock for breeders. He would kill off a proportion of the small stock, and keep the very best selected animals for breeders, and that seems to me is precisely what we ought to do in the case of the lobster.

A METHOD OF LOBSTER CULTURE

By A. D. Mead, Ph. D.

Member of the Rhode Island Commission of Inland Fisheries

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of one hundred dollars in gold offered by Hermon C. Bumpus for an original and practical method of lobster culture

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A METHOD OF LOBSTER CULTURE.

By A. D. MEAD, Ph. D.,
Member of the Rhode Island Commission of Inland Fisheries.

THE PROBLEM.

Artifical breeding ought not to be content to do at its best only what nature does unaided. It obtains its real justification only when it is in a position to surpass nature in her achievements. Only thus can it accomplish the task set it—to fill up the gaps caused by years of excessive fishing. (Professor Ehrenbaum, in Mitteilungen des Deutschen Seefischereivereins, Bd. 23, Juni 1907.—Translated.)

In the case of the lobster, nature has made adequate provision for the protection of the eggs up to the very time they are hatched. As is well known, the eggs laid in July or later in the summer or in the early fall are carried attached to the swimmerets under the abdomen of the female lobster, and there are protected until the following June or July, when they hatch out (fig. 9, pl. XI). The young lobsters, also, when they have successfully passed through three moults and have attained the so-called "bottom stages" are equipped with structures and instincts which fit them exceedingly well for holding their own in the struggle for existence; but there intervenes between the hatching and the attainment of the first bottom stage a brief period of two or three weeks in which the young lobsters, having lost utterly the protection of the mother animals, and not yet having acquired either the structure or the instinct which would give them a reasonable degree of individual security, are exposed and helpless to an extraordinary degree.

Those who have studied the question of lobster culture agree that this short interval may properly be called the "critical period" in the lobster's life—the one in which occurs by far the greatest mortality. That the species has maintained itself without diminution (until the recent inroads by man) in spite of this unprotected period may be explained by the enormous productivity of the individuals. A lobster of ordinary size—say 12 inches—produces at one time, according to Herrick, an average of about 20,000 eggs, which are so well protected that practically all of them hatch. This excessive productivity, however, though a potent means of protection to the species, affords no protection to the individuals.

To one confronting the problem of lobster culture these cardinal facts in the natural history of the lobster point out clearly and exactly the line of attack. We can hardly expect to increase the number of eggs per lobster (and fortunately the number is at any rate very large) or to improve on the natural method of protecting and hatching the eggs, for up to the time when the eggs are actually hatched there seems to be little loss in nature. It is during that period directly after hatching, when in nature the larvæ are neither protected from without nor equipped for self-protection, that the great opportunity offers to "surpass the achievements of nature" by protecting these individuals. Not only is this period the weak spot which artificial culture may be expected to strengthen, but the superabundance of larvæ normally produced for sacrifice is advantageous because it furnishes readily the material for cultivation. Still another condition particularly favors the cultivation of lobsters: It is that the critical period between the perfectly protected eggs and the well-equipped bottom-living lobsterlings is so short (only two or three weeks). Altogether, then, there would seem to be no doubt that the greatest practical results of lobster culture can be obtained by concentrating efforts upon protecting the fry through the critical larval period. This has been quite generally and independently recognized as a fact by those who have studied the lobster problem, and it has been an incentive to the many attempts made by experimenters on both sides of the Atlantic to rear lobsters through the larval stages. It has been, likewise, the incentive to a continuous series of experiments and operations extending over exactly ten years, which have resulted in the method of lobster culture presented in this paper.

CHARACTERS AND HABITS OF LARVAL LOBSTERS.

It is a necessary preliminary to an intelligible account of the method itself to sketch briefly the habits of larval lobsters and to indicate some of the peculiar difficulties which the method has to overcome.

Hatching.—The hatching of the ripe eggs of an individual female lobster is a gradual process requiring at least several days and varying with the temperature of the water and perhaps with the lateness of the season. In the latter part of June, when nearly ripe lobsters are brought into the warm water of a shallow estuary, the hatching is accelerated. The fact of the gradual breaking loose of the eggs is undoubtedly of importance in the economy of the lobster under natural conditions, for it prevents the possibility of the swarming of the young fry and the attendant dangers of speedy recognition and capture.

When the larval lobsters first break out of the egg membrane they are closely coiled in the form of an oval spheroid with the terminal segments of the abdomen bent over the rostrum. In a few moments they straighten out and expand and then immediately take up the pelagic life and instincts which they retain until they reach the so-called "fourth stage," after shedding their skins three times.

Mode of swimming.—The young lobsters swim by means of vibratory movements of their exopodite appendages, which stand out like blades from the thoracic legs, and the swimming is augmented by irregular jerky strokes of the very muscular "tail" or abdomen, which, in all the larval stages, is bent at a considerable angle to the cephalothorax. The swimming must be characterized as slow and weak when we have in mind for comparison that of most young fishes. At any time during the three larval stages the fry can easily be picked out by means of a small scoop, or even with the hand.

In general, too, the swimming seems to be aimless in direction, so that the fry are easily carried along by the slightest current. This statement, however, though generally true, requires qualification, for under the influence of special stimuli the movements often become directive. The larvæ respond to varying directions and intensities of light and, in experimental tests, to the direction of electrical currents. They avoid, in many cases, light-colored objects if near, and they are attracted by food to a rather slight degree. They will go only very short distances, however, after particles of food or living prey. During all the larval stages they exhibit practically no instinct of fear and, while they avoid light surfaces, they do not try to escape capture. The heliotropic and photopathic reactions and what may be described as the general aimlessness of movement are things to be reckoned with in developing a practical method of lobster culture.

Food.—The natural food of the lobster must, of course, consist of pelagic organisms. In an examination by Dr. L. W. Williams of the stomach contents of larvæ in all three stages taken from the rearing bags at our station,[a] a large percentage were shown to have fed upon copepods and diatoms. The young lobsters, however, are not distinctly fastidious in this respect, and the nature of the stomach contents of the fry in their natural habitat would doubtless be found to vary according to the variety of available pelagic food.

Moulting and the larval stages.—The instincts and behavior and the general appearance of the three successive larval stages are generally similar in respect to the features just referred to. The stages are, however, structurally well defined and readily recognized, there being for each a number of clearly diagnostic peculiarities. (See text figures p. 224 and 225.) Among the most obvious and easily recognizable are, for the first stage, the small size of the larvæ and the absence of swimmerets on the under side of the abdomen; for the second stage, the somewhat increased size, the presence of several pairs of swimmerets and the absence of "tail fins" or the lateral appendages of the penultimate segment; for the third stage, the presence of both swimmerets and "tail fins." All stages have the exopodite swimming appendages and the corresponding pelagic habit; none has the functional chelæ or "big claws" of the adult lobster.

According to the observations made by Doctor Hadley at our station the average measurements of the three successive larval stages are 8, 9½, and 11

[a] Station of the Rhode Island Commission of Fisheries at Wickford, R. I., on Narragansett Bay.

millimeters, respectively. There is, however, a considerable range of variation in size, particularly in the second and third stages, and there is good evidence that in general the larger specimens are the better fed. For this reason the average size of the lobsters of the various stages in particular rearing experiments forms, perhaps, a basis for judging whether the lobsters are doing well or not.

The length of the combined larval stages varies greatly and is directly and powerfully influenced by the temperature and food. It ranges from nine to

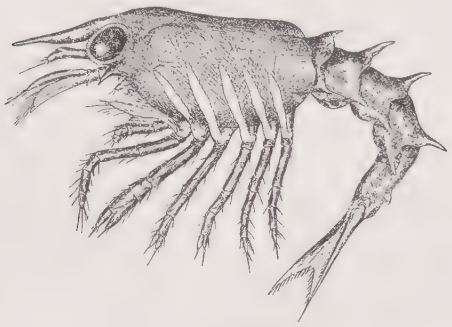

FIG. 1.—First stage.

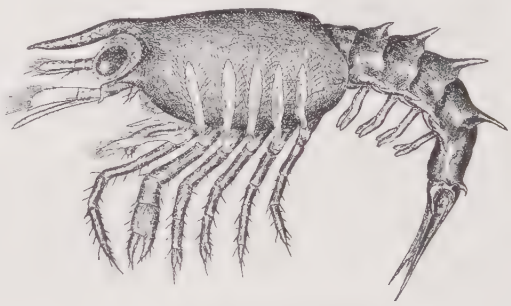

FIG. 2.—Second stage.

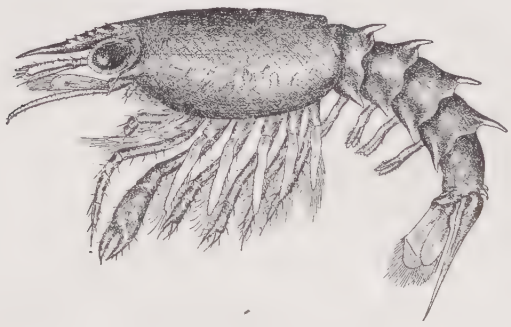

FIG. 3.—Third stage.

LARVAL LOBSTERS, LATERAL VIEW.

more than twenty-five days (twenty-one days is extremely long at Wickford). From the viewpoint of practical culture, the length of the total larval period is of very great importance, though the duration of the first, second, and third stages severally does not seem to be so.

DIFFICULTIES IN REARING.

In artificial culture, of course, the fry must be confined in large numbers, and it is practically impossible to separate them from one another. Therein appears an initial difficulty which all experimenters have had immediately thrust upon them. The fry, under these circumstances, at once exhibit a most

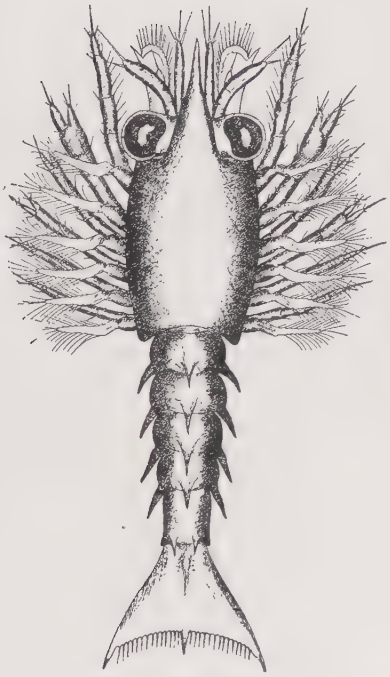

FIG. 4.—First stage.

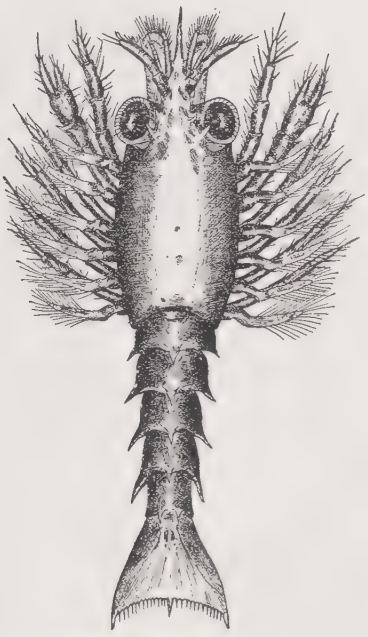

FIG. 5.—Second stage.

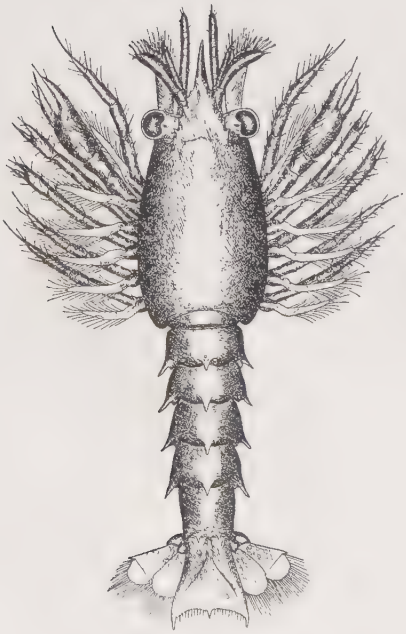

FIG. 6.—Third stage.

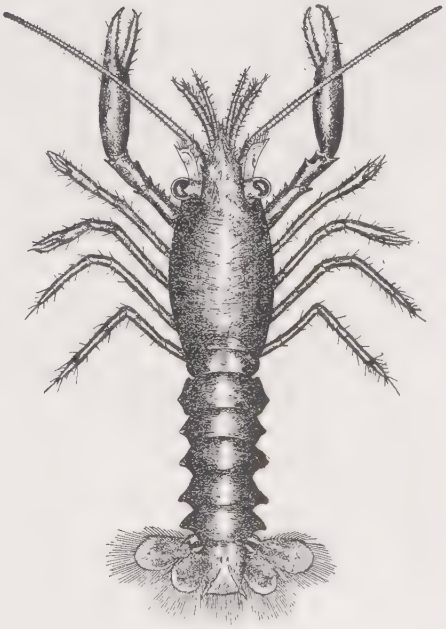

FIG. 7.—Fourth stage.

LARVAL LOBSTERS, DORSAL VIEW.

unnatural and vicious cannibalism which Professor Morgan might well have added to his enumeration of characteristics impossible of development through natural selection and the survival of the fittest, for it can hardly be exercised at all under natural conditions. But whether this evil instinct arises from one or another biological antecedent cause or is a special inspiration in each particular case, its reality is a constant and serious menace to lobster-culture operations. The cannibalistic tendencies are manifested as soon as the fry are hatched and continue throughout the larval period and, for that matter, even far beyond it. Not only do the larger and stronger specimens devour the weaker, but individuals of equal strength attack one another, and, apparently, some initial advantage determines the outcome. During the moulting period the mortality from these sources is naturally aggravated, because it is easy to tear to pieces the soft-skinned, freshly moulted individuals, while they, on their part, are unable to fend off attacks.

Swimming habits.—The comparatively aimless and weak swimming habit which characterizes the larvæ of the first three stages would seem, even in nature, to afford no protection, but for cultural operations, where large numbers of larvæ are given the restricted liberty of a small arm of the sea or are more closely confined in cars of any sort, it contributes to one of the most exasperating difficulties. For example, it happened that when the fry in one of the early experiments of this series were placed in a small cove or inlet from the sea, especially prepared and apparently well adapted to their requirements, they were carried out by the first ebbing tide, and when, subsequently, a screen was stretched across the gateway they were carried against it and left stranded high and dry. In the many attempts to confine them in various forms of cars, when the current was allowed to pass through to prevent stagnation, a like result followed—the unresisting fry were always finally borne against the sides or bottom.

Once upon the bottom the larval lobsters are utterly helpless; they lie upon their sides or backs beating the water with their exopodite "fins" and "kicking" with the whole body. They can not crawl; their only salvation is to "kick" themselves loose from entanglement and once more rise in the water. When confined in considerable numbers, even in still water, they inevitably find their way to the bottom as a consequence of their aimless drifting mode of swimming. There they accumulate in corners, pockets, or eddies, and, entangled in débris, they fight and eat one another until, from injury or suffocation, they all perish. For the full appreciation of these difficulties there must be, however, the personal recollection of particular rearing bags in which from day to day the precious living larvæ vanished from sight, and of the quarts of bright pink colored dead specimens mixed with dirt and silt and remnants of unused food that came into view when the bag was raised for inspection. In one of the

earlier experiments 5,000 handsome first-stage larvæ, appropriately designated from their condition the "gilt-edged lot," were placed in a new scrim bag 12 feet square and about 4 feet deep and were carefully tended. Out of the number only two individuals came successfully through to the fourth stage.

Light reactions.—As far as the movements of the larval lobsters are not aimless, they seem to be directed mainly by responses to light stimuli, and vary according to the intensity, color, and direction of rays. They also seem to be modified, indirectly, by background. Doctor Hadley in a study made at our station of the behavior of lobsters observed that the character and responses bore a fairly constant relation, not only to the stage, but to the period within the stage. In cultural operations, where cars are used, the photopathic responses of confined lobsters tend to bring them together into close quarters and are often therefore inimical because of the encouragement that this gives to cannibalism. In attempts to retain the fry in pounds or small estuaries, these responses would very likely tend to carry the lobsters to the shore, to be entangled in the vegetation or stranded at the ebb tide.

Parasites.—External parasites, including stalked protozoa, fungi, diatoms, etc., are often a plague to the confined larvæ. They grow upon the shell and so encumber the larvæ that feeding and moving and breathing also are difficult or impossible. Not infrequently, in fact, the larvæ are so completely covered with these foreign growths that they can hardly be recognized. The parasites are got rid of at each moult, but often they so weaken the larvæ that moulting itself is made impossible. The danger from this source is greatest when, by reason of the low temperature of the water, the duration of the periods between moults is increased.

Food.—Not the least of the difficulties connected with rearing lobster fry is the providing of proper and available food. In small experiments the live copepods and other pelagic food natural to the lobsters in these stages can be supplied, but on a large scale this is not an easy matter. Naturally, food that sinks to the bottom can not be reached by fry that normally swim or float.

Requisites of water, etc.—The foregoing facts regarding the characteristics of the fry in general and the peculiarities which they manifest when in confinement have to be taken into consideration in any attempt to rear the lobster through the critical period of its life. To these considerations must also be added the important question of an adequate supply of water, uncontaminated by chemical or bacterial impurities, constantly furnished with the proper amount of oxygen, and sufficiently free from injurious gases arising from the metabolism of animal or bacterial content. Finally, in any method of lobster culture there must be taken into consideration its practicability when applied on a large scale and its feasibility with regard to the cost of operating.

THE METHOD.

ESSENTIAL FEATURES AND POSSIBLE VARIATIONS.

A method by which lobsters can be reared through the larval stage in such proportions and numbers and at such a cost that it may be called a "practical" method has been gradually evolved at the floating laboratory of the Rhode Island Commission of Inland Fisheries at Wickford, R. I. (fig. 1, pl. VII). Essentially, the method consists of confining the larval lobsters in cars, either of porous material or provided with screen "windows," set into the ocean itself, and of maintaining within the cars, by mechanical means, a continuous gentle current of water having a rotary and upward trend. In details the method allows of wide variation. Good results have been obtained in small cars made out of water pails; in cars approximately 1 foot, 3 feet, 6 feet, and 10 feet in horizontal diameter and 1, 3, or 4 feet deep; and in either square or circular cars of cotton or linen scrim, of bobbinet, of canvas, or of wood. Any constant motive power can be used, according to the exigencies of particular cases—steam, hot-air, or gasoline engines; spring, weight, or water motors; or the water can be stirred by hand, with much labor but good results, as in our early experience. Various forms of power transmission may also, of course, be utilized; belt and rope drives over pulleys and sheaves, and steel shafting with mitered gears, worms, etc., have all been successfully utilized.

HOW THE METHOD MEETS THE DIFFICULTIES.

The way in which this very simple method overcomes the many difficulties of confining larval lobsters may be described in general terms as follows: In the first place the rearing cars are placed directly in the sea, and thereby all the disturbing factors so difficult to control in case of aquarium water which has been pumped and forced through closed pipes, stored in tanks, aerated by air pumps, etc., are at once avoided, and at the same time the various known and the subtle unknown requisites of healthy sea water are assured. The continuous upward spiral current of the contained water is the panacea of numerous troubles. By the upward trend of the current the larvæ are kept always afloat, which is their normal condition and the only one to which they are by structure and habit adapted. The strength of the current easily overpowers their own weak efforts at swimming, sweeps them round and round, and effectually prevents their congregating in common response to the stimuli of light.

When the fry are prevented from getting to the bottom and from congregating anywhere, several difficulties vanish. The effects of cannibalism, which constitute perhaps the most serious difficulty of all, are thereby greatly alleviated, for the fry are to a comparatively great extent prevented from reaching one another, and of course the disastrous effects of their becoming stranded on the sides or lying entangled and fouled at the bottom are also obviated.

Another most important function of the current is the holding in suspension of solid particles of food, so that they come within easy reach of the larvæ. Incidentally, also, it increases the supply and availability of pelagic living food, for the latter is drawn into the car through the bottom and kept alive by normal conditions of the water. An adequate supply of available food is perhaps the most efficacious preventive of cannibalism.

The maintenance of normal conditions of water in a car is also accomplished by this method. The temperature and density of course vary little from that of the surrounding water. The water is constantly renewed either through the porous sides or, in the case of wooden cars, through screen windows in the bottom, egress being allowed for by screens in the sides. Since the current is internal and mainly tangential to the sides of the car, the fry are not carried violently against the ex-current screens, as in the case of a tidal current passing in one side and out the other. There is not much need of rapid renewal of water, however, because the water is continuously brought to the surface by the upward trend of the current, where by exposure to the air it is recuperated with oxygen and relieved of waste gases due to the metabolism of contained animals or the decomposition of unused food.

In a word, it may be said that by this method the pelagic lobster fry may be kept in confinement and under observation in inclosures of natural water, protected from their usual predatory enemies, maintained in natural pelagic condition by being prevented from going to the bottom, provided with either living or artificial food held in suspension, and that the tendency to cannibalism, always evinced when the fry are confined, can be considerably mitigated.

APPARATUS.

The particular form of apparatus by means of which this method has been successfully applied to the rearing of lobster fry during the last few years at Wickford is in some respects a special adaptation to the establishment in connection with which it has been evolved, and certain details of construction are vestiges of former experiments too good to be cast aside, but not to be exactly copied in new construction. As it stands to-day, the apparatus consists of a houseboat built like a catamaran of two pontoons, with a "well" or open space between them, originally intended and used, indeed, for holding experimental cars. At both ends the space between the pontoons is decked and on each deck is a small house. The houseboat floats on the water, moored securely in a small cove directly over the channel in a good tideway (fig. 1, pl. VII). It forms the nucleus of a collection of skeleton rafts which nearly surround it and which all together occupy a considerably larger area than the houseboat itself. Four rafts, 19 by 75½ feet, lying two on either side of the houseboat, contain the cars for hatching and rearing lobster larvæ. The rafts of each pair are bolted fast together and buoyed by barrels (fig. 1). The inside rafts on either side of

the houseboat are fastened to the latter with eyebolts sliding over vertical rods to allow solely for up-and-down motion. Each of the four rafts contains six rearing cars, 10 by 10 feet square and 4 feet deep, so arranged that they can be held down in place or raised out of the water to be cleaned (fig. 4, pl. VIII). The rearing cars are provided with removable windows covered with 16-mesh bronze woven wire screens to allow for renewal of water and to prevent escape of fry. There are two windows about 2 feet square on the bottom and two long narrow ones in the middle of two opposite sides.

For several years previous to last summer canvas bags about the dimensions of these boxes and provided also with screen windows were used almost exclusively. They equaled or perhaps surpassed the boxes in point of efficiency when they were in perfect condition, but were less durable and were more difficult to clean.

The apparatus for keeping the water in motion consists of a two-bladed horizontally placed propeller of about 4½ feet radius not unlike those sometimes in use over restaurant tables (fig. 3 and 4, pl. VIII); the latter, in fact, suggested their adoption. The propeller blades are hung inside the car near the bottom and are made to revolve slowly—about nine revolutions per minute. The motive power for the propeller is furnished by a gasoline engine situated in one of the houses and connected with the propeller shaft by a system of steel shafting and mitered gears (fig. 1, 2, 3, pl. VII and VIII). Each propeller can be thrown in and out of gear independently.

HATCHING METHODS.

Handling the egg lobsters.—The method now used in hatching the eggs is simple. The old female lobsters carrying eggs about ready to hatch (fig. 9, pl. XI) are put directly into boxes and the paddles are set in motion. As the old lobsters crawl about on the bottom of the cars, the eggs hatch out one by one and the larvæ, caught immediately by the upward revolving current, are carried up and off the bottom as they are in the ocean. Twenty to 30, or even 50 to 100, lobsters may be put in one car. When the number of old lobsters is large, we have found it well to replace the long propeller by a shorter one hung somewhat farther from the bottom so that the old lobsters will move freely over the bottom with tails extended and not crowd up into the corners. Screens placed over the top of the box, thereby shading them from the strong light, also help to prevent crowding (fig. 7, pl. X). As soon as a sufficient number of fry have hatched out the old lobsters are removed to another car to repeat the operation. The length of time required to hatch out a full complement of fry in one box varies, of course, according to the various conditions; that is, the number of egg lobsters, the condition of the eggs, the temperature of the water, etc.

Precaution as to age of fry.—It is of great practical importance to have a full complement of fry hatch out as quickly as possible—within at least one day—so that all will be about the same age. Otherwise, when the fry moult the older

individuals, having passed through the moult and recovered their strength and appetites, are very destructive to the smaller or freshly moulted larvæ. The effects of this discrepancy in the ages among lobsters of one batch are especially injurious when the older individuals reach the fourth stage, for the fourth-stage lobsters are endowed with strength, sagacity, directive power of movement, and voracity of appetite far beyond that of the other stages. When, through a difference in age, a number of lobsters enter the fourth stage considerably in advance of the others, they become veritable "sharks," as they are jocularly called by the attendants. On this account in the first experiments with wooden cars a considerable loss was sustained because certain boxes were reserved as hatching boxes and the fry rather than the "hens" were periodically removed (fig. 5, pl. IX). It being impossible to get them all out at one time, those that remained were often taken out together with a younger lot and later on became "sharks" to this brood.

Circulation current.—For the benefit of the fry there is no doubt an optimum current within the car. The current can be controlled to a surprising degree by manipulating the propellers, although the number of revolutions per minute remains constant. A slight inclination to the blades makes a current very slow, while the maximum inclination creates a current like a mill race. The length of the blades, the amount of taper from base to apex, and the height of the blades in the water cause different effects in the character of the current; for example, the relations of the rotary and the upward components of the current can be thus controlled and varied within wide limits. By these and other variations the fry can be made to scatter evenly at all depths and distances from the center or to occupy various zones or strata. Experience and judgment must decide the question of optimum current at each particular phase. In general, it may be said that a gentle, even current made by a long, well-tapered blade and slight angle of inclination is usually best.

Containers for eggs and fry.—When the rearing was done in canvas bags the old lobsters were confined in crates suspended in the bags, because, if let loose in the bottom, they were apt to tear the canvas. The crates were necessarily less spacious and had the objection of being in the way of the newly hatched fry, which were sometimes swept against them with considerable force by the current. To the other advantages of the wooden car as compared with the canvas bag must be added its capacity to function as a hatching pen. The design and construction of these wooden cars, together with many other recent improvements, should be credited to Mr. E. W. Barnes, the superintendent of the station.

In the beginning of the experiments at Wickford the fry were transported from the Woods Hole hatchery by the Bureau of Fisheries, with whom we were in cooperation. Later experiments showed that the eggs could be stripped off in the usual way and placed in small rearing bags, where they would hatch.

From these the fry were transferred to rearing cars. This method gave place to that of putting the ripe egg lobsters in shallow crates floated near the surface in the big canvas rearing bags, and then the two modifications just described were introduced.

CARE OF THE FRY.

After the fry have been hatched and transferred to the proper rearing car they respond well to careful treatment, and the degree of success of an individual experiment depends to a large degree on the care that is given.

Screens.—Attention to the condition of the screens is worth while, for the intake and outflow of water can thus be regulated and, incidentally, the fine particles of food can be retained in the car for longer or shorter time by this means. The screens which we have used have been made of copper wire, bronze, galvanized iron, galvanized steel, scrim, and painted wire of various meshes and sizes of wire or thread. None is thoroughly satisfactory. They are all apt to clog up or to tear easily. It is to be hoped that the perforated sheet brass or bronze, which has been tried by Professor Gorham to his satisfaction in small experiments, will prove to be a great improvement.

Food.—An appropriate and available food supply sufficient in quantity to fulfill the demands of healthy growth is, of course, a prime requisite in any fish culture, but in the case of the lobster larvæ even this may not be adequate. Not only should the fry have food enough for their healthy growth, but they should never be allowed to go hungry. From hunger to cannibalism is a short step, and although, by means of the current, the fry are kept from congregating, and danger from cannibalism is, therefore, greatly lessened, there still occur chances of individuals coming momentarily in contact with one another, and, if hungry, they make the most of these opportunities. When not hungry, and when the cannibal instinct is not aggravated by the crowding together, they are fairly peaceable.

The question of the best food for the lobster fry is still open. There are many kinds that the fry will eat, and fortunately by means of the stirring apparatus small pieces of almost any kind can be held suspended and therefore made available, but the fry have preferences, and, furthermore, the choice must involve the consideration of cost, the labor of preparation, waste, and the effect upon the water in the cars of the grease or decaying residue.

In some of the earlier experiments several years ago the highly epicurean diet of lobster liver was offered, and the young larvæ, innocent of its antecedents and, as it proved, unaware of its consequences, devoured the finely divided morsels ravenously. This diet did not agree with them and was discontinued partly on this account and partly because for operations on a large scale there were financial objections to its use. Shredded codfish, finely cut or ground fish of various kinds, clams, mussels, raw beef, beef liver, boiled beef, and many other foods have been tried. The fry are extravagantly fond of fresh fish,

especially the strongly flavored and oily varieties, but the pieces uneaten foul the car and are therefore objectionable. Clams cut out and finely chopped or ground have been in very general use with us. The expense, however, of digging and opening and the considerable waste in the larger pieces of tough muscle, together with the amount of decayed residue which accumulates in the course of two weeks during which the fry usually remain in one car, are objections to its continued use.

In a careful series of food experiments at our station Doctor Emmel decided, after using clam, liver, beef, and some other foods, that chopped raw beef gave best results, all points considered. However, with a large quantity of fry to feed, it was found to be difficult to prepare cheap raw beef finely enough divided for practical use. Boiled beef coarsely ground (Hamburg steak), boiled, and ground again, and then beaten up in water with an egg beater, was used with gratifying results during the latter part of the present season. It has the advantage that it is easily prepared, even though the cheapest and toughest is chosen, and that when prepared in this way the pieces are small and correspondingly numerous. The particles are readily held in suspension, and when put into the water little by little with a long-handled scoop or shaken through a fine netting (fig. 6, pl. IX) they form a cloud of light-colored and easily visible particles and are distributed so evenly that they are available at every feeding to all the thousands of individuals in the car. Prepared in this manner, the beef leaves scarcely any residue; most of the uneaten finely divided pieces are carried out gradually through the windows. In its use one prime precaution must be taken; it must not be allowed to become stale or previously soaked with water. Care should also be taken to put the raw beef into boiling water and so to coagulate and conserve its albumens.

For the reason alluded to, namely, to keep the larvæ not only well fed but constantly satiated, thereby preventing cannibalism, it is necessary to feed them often, and we adopted the schedule of feeding every two hours through the night and day. Even with the best possible food—and this has yet to be discovered—there is a "knack" in feeding, and it is one of the points in the care of the fry which repays careful attention, for, besides having the advantages just mentioned, adequate food undoubtedly increases the rate of growth and shortens the larval period.

Parasitic growth.—The dangers from diatomaceous, fungous, and similar parasitic growths are especially serious when the time between moults, due to cold water or poor food, is relatively long. For this reason the temperature is a factor to be considered, when possible, in locating a hatchery. At our station the duration of the whole larval period is from nine to (rarely) twenty-one days, most of the larvæ hatching in about twelve to fourteen days. We have found that shading the cars, as Professor Gorham recommended, seems to prevent to a marked degree the growth of diatoms, and also that in the wooden cars recently

adopted the annoyance from this source is very slight when the cars are shaded. The insides of all of the boxes were painted, four of them white and the rest green. We could not see that either color had an advantage, judging from the output of fry. Whether the comparative immunity from diatoms of fry in boxes as compared with those in canvas bags was due to the painted surfaces of the wooden sides or to some other factor it is difficult to say. Animal growths, barnacles, molgulas, oysters, mussels, etc., were abundant even on the painted surfaces, and were scraped off each time the cars were raised. Canvas screens on frames (fig. 7, pl. x), set up like the sides of a roof so as to afford shade and to shed rain water, which occasionally comes down in such quantities as decidedly to freshen the upper strata of water, are strongly to be recommended.

RESULTS.

CRITERIA OF EFFICIENCY.

As was stated at the outset, this series of experiments and operations was undertaken in the conviction that the paramount problem of lobster culture was to raise the larvæ to the fourth or lobsterling stage. It has been constantly borne in mind that a method of doing this to be practical must be able to produce large quantities and without too great expense either for the cost of the plant or for operation. Further criteria of efficiency are, first, the proportion of fourth-stage lobsters to first stage, and, second, the number of "fours" to egg lobsters, provided, of course, that the egg lobsters on hand do not overcrowd the capacity of the particular plant. In placing a value upon proportions of "fourth stagers" to newly hatched fry, the number of fry dealt with in a single experiment has been considered; e. g., a proportion of 50 per cent carried through in an experiment with 500 or 1,000 fry can not fairly be compared with the same proportion in an experiment in which 5,000 or 20,000 fry are used. We have allowed ourselves also to mark our progress and the value of the method by comparison, first, with our former results, and, second, with the experiments undertaken elsewhere having the same end in view.

YEARLY PROGRESS AND OUTPUT.

Since this year happens to be the decennial of this particular series of experiments and operations, the presentation of a short summary of yearly results in regard to total output is appropriate.

In 1898 Doctor Bumpus, now the honorable president of this congress, and at that time director of the United States Fish Commission laboratory at Woods Hole and member of the Rhode Island Commission of Inland Fisheries, had the faith and courage to undertake a new series of experiments in rearing the larval lobsters. Judged by the ingenuity put into them, and the experience and encouragement got out of them, these experiments during the first year were

successful, though the number of fry reared was small. The total output is summarized in the report of the work in these words:

> Several lobsters were actually raised to the stage when the characters of the adult are assumed—the fourth moult.[a]

The next year, 1899, the results were better because of the use of "a large bag of scrim made after the fashion of a fish pocket and hanging down into the water from a square floating frame." The output is given in the following words:

> By the methods above described, and after many failures, accidents, and reverses, we succeeded in raising several hundred lobsters to the fourth stage.

During the following season, 1900, several lots of newly hatched fry were transported from the United States Fish Commission station at Woods Hole to the new floating laboratory of the Rhode Island Commission of Inland Fisheries at Wickford, R. I. (the two commissions working in cooperation), where further experiments with scrim bags were started parallel to those still being conducted at Woods Hole. At the floating laboratory at Wickford the trials and reverses of the previous year at Woods Hole were again experienced, but the experiments were under the eye of the person in charge, by night as well as by day, because the small houseboat functioned as a residence. The greatest virtue of the loosely hung scrim bags consisted in the undulatory "peristaltic" movements, due to wind and tide, which tended to keep the lobsters off the bottom, but it was observed that during the nights there were periods of dead calm and of slack tide, when the fry sank to the bottom and died. This led to the simple conclusion that if the fry, left to themselves, persisted in sinking to the bottom to die they must be stirred up and prevented from sinking; so after this they were stirred with an oar continually night and day. The total reared to the fourth stage was 3,425. The results showed unequivocally that the proper principle had been discovered, and immediately plans were laid to substitute a mechanical apparatus by which this method could be less laboriously carried into effect. Curiously enough, some large two-bladed fans revolving over a restaurant table for the purpose of driving away flies suggested the type of apparatus suited to the purpose, and this type has been in use ever since.

The next year, 1901, the United States Bureau of Fisheries again cooperated with the Rhode Island commission. Some of the fry were imported from Woods Hole and some were hatched at Wickford. An apparatus for using the two-bladed propeller was designed and installed by Mr. G. H. Sherwood. The results confirmed the correctness of the principle, and the output for the year was 8,974.

During the subsequent years the method has been developed and the apparatus again and again remodeled to incorporate the results of our failures and

[a] Bumpus, Twenty-ninth Annual Report of the Rhode Island Commissioners of Inland Fisheries, 1898, p. 98.

successes and in the effort to obtain results on a scale large enough and with cost small enough to deserve the adjective "practical." The total outputs for the years are:

1898	(a)	1902	27,300	1906	c189,384
1899	(b)	1903	13,500	1907	d294,896
1900	3,425	1904	50,597	1908	e322,672
1901	8,974	1905	103,572		

The rearing of considerably over 300,000 lobsters in the small plant at Wickford recalls the confession of faith written ten years ago, at the conclusion of the first season's work:

> We know perfectly well that many others have failed in doing what we attempt, but until we are thoroughly convinced that the young lobster can not be "brooded" we propose to continue our work.[f]

Manner of determining output.—It was early realized that "estimates" of the number of lobsters in experimental work are practically worthless and therefore all the fourth-stage lobsters which are taken account of at all (many thousands of others have accidentally escaped) have been individually counted. Within the last few years, when the numbers have run up into hundreds of thousands, the operation of counting individuals has consumed much time, but the satisfaction of accuracy in results has been sufficient compensation. A comparatively easy and very accurate method of counting is now in use. The "lobsterlings" are dipped out of the hatching boxes with flat woven-wire strainers which take up from one to twenty at a sweep; these are recorded on an automatic counting register held in the hand. The count at each sitting is then posted (fig. 7 pl. x).

It is of little use to estimate the number of a lot of first-stage fry. More than once the lots so estimated, even by experts, have yielded not more than 10 per cent of the estimated number; sometimes, no doubt, they would run considerably over. For this reason, in order to ascertain the proportion of newly hatched fry to the fourth stage, the individuals must be counted both before and after the experiment. This is a rather tedious process, but it is warranted and necessary when new methods or new devices of construction are tested for their relative efficiency.

Tested by this method both the large canvas bags used until this year and the present boxes have yielded on several tests 40 per cent of fourth-stage lobsters from lots of 20,000 newly hatched fry. In one test of the canvas bags 48.2 per cent were obtained in a 20,000 lot. In testing for relative value of foods in

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a "Several."
b "Several hundred."
c 24,800 to fifth stage.
d 4,900 to fifth stage.
e 5,481 to fifth stage.
f Bumpus, op. cit.

1907, 40.6 per cent and 39 per cent were obtained in two respective tests, while one of the boxes yielded 42 per cent. About 40 per cent may be considered a fair yield for lots of 20,000 under the present system of operation. By using more fry more fourth-stage lobsters can be obtained from a single car, but the percentage probably falls.

There is another very different point of view from which the efficiency of the present method may be judged, namely, the number of fourth-stage lobsters which it will produce per egg lobster under fair conditions. Toward the latter part of the season two years ago, when the supply of eggs from the ordinary source had suddenly been cut off, 56 egg lobsters were received from Noank through the courtesy of the Connecticut Fish and Game Commission. From these there were hatched and reared to the fourth stage 84,896 young lobsters, giving an average of somewhat over 1,500 per egg lobster.

SUMMARY AND INTERPRETATION.

Summarizing the actually obtained results of rearing lobster fry to the fourth stage by the method herein described: Since the present method was first put into operation in its crude form where the water was stirred by an oar the output has each year (with one exception) increased. The extremes are represented by the total of 3,425 in 1900 and of 322,672 in 1908. The grand total for the eight years is 1,014,320, more than half of which were produced in the last two years. With lots of 20,000 newly hatched fry from 40 to 48 per cent (counted) have been carried through to the fourth stage frequently, and 40 per cent may be said to be a fair average to expect under good conditions. From 56 egg lobsters nearly 85,000 fourth-stage lobsters were obtained, showing an average of about 1,500 per individual.

In order to interpret these results fairly, there are certain things which deserve consideration. Even when operating on a practical scale, we have been feeling our way over new ground to further improvement of the method. Not a year has passed without decided changes in the method or the apparatus. While this procedure leads to the best final outcome, it does so at a sacrifice of immediate results. Accidents, also, of certain classes—for example, the loss of larvæ through broken screens—must be charged against the present apparatus and not against the method. Delays in construction, difficulty in getting egg lobsters, etc., may be due to misfortune or to mismanagement, but do not affect the permanent value of the method.

Capacity and efficiency of plant.—The plant as it stands to-day must be judged by the results actually attained; but having watched closely its operation I may venture the personal opinion that it has not yet produced to its full capacity and that the 24 cars are capable, under good conditions and with allowances for inevitable mistakes, of hatching and rearing 500,000 lobsters in the

six or eight weeks which constitute an average season. This is a conservative estimate based on the following deductions: If all the 24 cars were filled three times, allowing two weeks for passing through the moults, with an average output per car of 10,000 each time (which is considerably below frequent actual production), the total output would be 720,000. With a constant supply of fry sufficient to fill the plant to its full capacity throughout the season, this estimate could probably be raised.

As has been stated before, many features of the present installation are to be considered as vestigial structures and others as designed for one function and adapted to another in the course of the evolution of the plant. A new plant, therefore, built to operate the same rearing cars would be different in many details. The cost of a plant capable of duplicating the work of the one at Wickford has been calculated by Mr. E. W. Barnes, superintendent of the Wickford plant, at approximately $2,000, specified as follows:

COST OF A REARING PLANT CONSISTING OF 24 REARING BOXES CAPABLE OF TURNING OUT OVER 500,000 LOBSTERLINGS IN A SEASON.

2½ horsepower engine	$200	24 boxes	$350
Houseboat	300	Miscellaneous supplies	200
Four rafts	350		
Gearing	400	Total	1,800

The above items have been figured economically but quite liberally, and in localities where materials can be readily secured the cost might be considerably lessened. The actual cost of rearing lobsters to the fourth stage is a little less than $3 per 1,000. This includes labor, food, gasoline, and in fact all necessary running expenses, but does not include the cost of egg lobsters.

This amount would, of course, vary with the time and place where the plant was constructed and also with the kind of materials used.

Self-protective ability of fourth-stage lobsters.—An acquaintance with thousands of fourth-stage lobsters from personal observation and through the special scientific studies of members of our staff increases even our former estimate of their superiority over the larval lobsters. Immediately after arriving at this stage they are able to crawl over the bottom, to burrow and hide, to fight, and to forage in most striking contrast to the larval lobsters in any stage of development. In the first few days of the fourth stage the lobsterlings are good swimmers—this is their "redeeming vice"—but the swimming is strong and bears no comparison to the aimless drifting movement characteristic of larval stages. The lobsterlings dart hither and thither in pursuit of food, and for the first time they show a decided fear and strive to avoid capture. When left in the rearing cars, which have a strong internal current of water, thousands of these lobsters are often seen all swimming mightily in one direction against the strong current for hours at a time; but these same lobsters when taken out of the car and put into another one provided with sand and gravel will often take immediately to the bottom and behave as if they had always lived in this habitat.

It is an interesting and important fact that the tendency to swim decreases rapidly during their sojourn in the fourth stage and also that they can be encouraged to live on the bottom by being brought into contact with it. These facts have suggested two modifications in the usual procedure in liberating lobsters—first, that of holding the lobsterlings in special rearing cars for a few days after they reach this stage, keeping up the current in order to keep the lobsters separated and to keep their food in suspension, and, second, that of liberating them in such a manner that they will immediately touch the bottom, in which case they are not so apt to make swimming excursions through the water. An ingenious device for the latter purpose has been invented by Mr. Barnes. The young lobsters are sunk in barrels which have the numerous holes for their exit so covered up that while the lobster can get out predacious fishes can not get in.

It is comparatively easy to care for fourth-stage lobsters. Space and plenty of food are about the only requisites. Like the fry, they are cannibals in proportion as they are hungry and crowded together; but unlike the fry, they control their own movements and go where they please, whether swimming, or crawling, or burrowing, and they have, moreover, a strong instinct of self-preservation.

Fifth-stage lobsters.—There is much to be said in favor of rearing lobsters to the fifth stage before liberating them, and this is not difficult to do, but requires space. In some experiments conducted without great care 80 per cent were carried from the fourth to the fifth stage in large lots of several thousand. In addition to the advantage in the matter of size, strength, and bottom-loving instinct, which favors the fifth-stage lobsters, an additional advantage lies in the fact that the duration of the fourth stage can be shortened by abundant feeding. Doctor Emmel showed in a most convincing manner that by feeding alone, all other conditions being identical, the duration of this moult can be varied from an average of eleven to an average of twenty-four days.

Liberation of young lobsters.—Every visitor at the rearing plant asks the embarrassing question, "What proportion of the liberated lobsters live to grow up?" Only once was a definite and satisfactory answer given to this question and that by a new recruit on his first day's duty.

In 1901 when the experiments began to indicate that a large number of lobsterlings could most likely be liberated from our establishment, investigations were started to find out whether the physical conditions of the waters of Narragansett Bay were such that the young lobsters could live here throughout the year. Of this there is now no doubt, for the specimens reared from the egg have year after year been kept over winter in cars sunk or floated in the harbor at Wickford. Several were kept for three successive years and finally were lost through accident.

EVIDENCE OF INCREASE IN LOBSTER SUPPLY.

The young lobsters have been liberated mainly in the upper half of Narragansett Bay, because for many years previous to our operations small lobsters have been conspicuously absent from these precincts, according to the statements of fishermen. Within the last three or four years a great many reports have come in of small lobsters from an inch to 4 or 5 inches in length being caught in the lobster pots and escaping through the slats when the pots were drawn up; also of small lobsters up to 8 inches in length dug out of the mud in the early spring by the clam diggers. These reports have been numerous and are increasing and apply to those particular districts in the upper part of the bay in which our lobsters have been liberated. They have occasioned remarks of surprise by the fishermen, because this region has been so long barren of small lobsters. Whether this can be taken as good evidence of the effect of liberating in these waters about half a million of young lobsters reared to the bottom stage (the number up to two years ago) is at present of course entirely a matter of opinion.

ECONOMIC EFFICIENCY OF THE METHOD.

At the end of an account of the method of rearing lobsters and of the results actually attained, a brief speculation with regard to the efficiency of the method from the economic standpoint may be permissible.

It is often true in biology that one can draw conclusions as to causes and effects from observation and comparison of normal occurrences. In the breeding of animals we seem to have a case in point. Fishes which produce many thousands of eggs at a time, but whose young are left almost utterly unprotected, often do not maintain so great a numerical abundance as do other species (like the dogfish), which produce only a very few individuals at a time, but give the young a high degree of protection.

While the relative values of the larval and fourth-stage lobsters can not, for a long time at any rate, be determined accurately by direct experiment, it would seem that a comparison of the breeding habits of the lobster and the crayfish would, as Ehrenbaum has pointed out, furnish data for a tentative valuation. Where the lobster produces at one time 20,000 fry (Herrick got an average of 21,351 eggs from 414 observations of 12-inch lobsters), the crayfish produces approximately 100 young (Ehrenbaum), which it protects to a stage comparable with the fourth-stage lobster. Assuming, then, that the 100 young fourth-stage lobsters and the 20,000 newly hatched lobster fry are of equal value for maintaining the species, the ratio of individual values would be 200 : 1. Our method of artificial culture is capable of obtaining 8,000 fourth-stage lobsters from 20,000 fry. It is able, therefore, by taking advantage of the lobster's great productivity, to obtain 80 times as many young of this particular advanced stage as are necessary for the maintenance of the species under natural conditions.

Fig. 1.—General view of house boat with floats attached, looking forward. The ends of the pontoons show at 1 and 2. The general relation of the rearing cars, alleyway, and barrels is seen in the right-hand floats.

Fig. 2.—Inside of box toward one corner. 1, Sleeve coupling for disjointing propeller shaft; 2, lever for throwing shaft out of gear; 3, train of mitered gears reducing speed of propeller shaft; 4, type of adjustable hangers in general use; 5, inside corner of box.

Fig. 3.—Floats from outer corner looking forward and toward house boat. The appearance of the car in the water and the gearing of the propeller shafts are shown in the nearest car.

Fig. 4.—One of the outside floats, car raised. The size and shape of the propeller is well shown.

Fig. 6.—Feeding by means of ground food shaken from a piece of netting. This prevents the larger pieces of food from getting into the car and also tends to prevent any sticking together of smaller pieces.

Fig. 5.—If the fry have to be transferred, they are scooped out on a flat net of this style and immediately shaken off into a tub of water, thence taken to the car prepared for them.

Fig. 7.—Method of counting fourth-stage lobsters. The awning is laid aside. The lobsters are caught up in the woven-wire dipper and shaken off into a bucket of water. In the left hand is held the automatic counter.

Fig. 8.—Improved towing car designed by Mr. Barnes from an old model. The egg lobsters are towed in this car, and fishes of various kinds have been towed for many miles with the most excellent results.

Fig. 9.—Lobster with eggs.

SEA MUSSELS AND DOGFISH AS FOOD

By Irving A. Field

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

SEA MUSSELS AND DOGFISH AS FOOD.

By IRVING A. FIELD,
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Of the two sources of human food, the possibilities of the land have been extensively studied while those of the ocean have been greatly neglected. Only a few observations are necessary to show how in ignorance and prejudice we have been overlooking and rejecting enormous quantities of valuable food material which are daily going to waste. With our rapidly increasing population the capacity of the soil to produce enough food is gradually approaching its limit. The resources of the sea, on the other hand, are practically unlimited. It is there our opportunities lie for meeting the increased demand for food which can be supplied at prices suitable to the laboring man's purse.

For the past three summers I have been employed by the Bureau of Fisheries to investigate the food value of certain hitherto unused marine animals. Of the forms studied I wish to speak to-day concerning the sea mussel and the smooth and the horned dogfishes.

A food substance to be considered a good marketable commodity must measure up well to four standards: It must be palatable, digestible, nutritious, and so abundant that it can be marketed at little cost.

To determine the palatability of the substances I was concerned with, the obvious method was for me to eat the substance and if no ill results followed persuade others to eat it, then average opinions in regard to it. The scientific staff of the Woods Hole Laboratory gave me first opinions in these tests. If they found the flavor good, I had the dish served on mess tables of the Marine Biological Laboratory at Woods Hole and to other persons interested enough to try it.

The second test, digestibility, involves several requirements—namely, the proportion of the substance that can be digested, the ease or rapidity with which it can be digested, and the manner in which the food is accepted by the stomach. Comparatively little is known concerning the relative rapidity of digestion of different foods within the body. Most of the current statements on the

subject are apparently based on experiments made outside of the body by artificial methods, imitating as closely as possible the conditions in the body, but not at all certain to be exactly the same. The artificial process takes much longer than the natural, yet proportionally the results are similar. For example, under natural conditions soft-boiled eggs will digest more quickly than hard-boiled ones. By the artificial method the process takes twice the time for each, but about the same proportionate results are obtained.

The third requisite, nutritive value, involves such questions as the ratio of edible portion to refuse, together with the chemical composition. A good food must supply for the least money a proper amount of nutrients to build and repair tissue and furnish energy for the body.

In the fourth place, the food must be so abundant and easily obtained that it can be sold reasonably cheap.

Any hitherto unused substance that measures up well to these standards ought to find its way into our regular bill of fare.

THE COMMON SEA MUSSEL.

Now the common sea mussel, *Mytilus edulis*, is one of our most common shellfish, in size varying from 2 to 4 inches long by about 1½ inches in diameter. The shell is very thin, of a violet color, and covered with an epidermis of shining blue-black. Mussels grow in great beds along both our Atlantic and Pacific coasts, and on the coasts of Europe and Asia.

Very little use is made of the mussel in this country, it being utilized only as bait to some extent and on Long Island for fertilizer. In Europe it entirely replaces as a food the common clam, which, though abundant, is used neither for bait nor food. Why the mussel is so neglected in America Ganong lays to the fact that the Indians superstitiously avoided it, while they ate the clam, thus leading the early white settlers to do the same thing, a habit that has been continued to this day. Only in and about New York City do we find a call for mussels as food, and this is limited.

From the standpoint of palatability I have unanimous testimony from scores of persons who have eaten mussels prepared in various ways—pickled, steamed, roasted, and fried. All acknowledged that in flavor they are superior to clams and quite equal to the oyster. I have unsought testimony from a lady who, with her daughter, spent a season on the Rhode Island coast and there learned to eat the mussel. She says:

> Two years ago we boarded a little while at Matunuck, R. I., 3 miles west from Point Judith. There are large mussel beds there, and we were told that they were particularly nourishing for people of weak digestion. My daughter was very fond of them. We boiled them like clams or roasted them on hot stones and found them most delicious, particularly when roasted. We ate quarts every day and have longed for them ever since. My daughter gained strength while there, and it was the only time that she seemed to gain during the summer.

From the standpoint of digestibility the mussels take high rank. Persons with weak stomachs can eat them without suffering any inconvenience. They can be eaten before going to bed and cause no discomfort. One of the men at the Woods Hole Laboratory who became very fond of them expressed his opinion that the pickled variety was just the thing to eat before retiring. Another man says that while meat does not ordinarily agree with him he can partake freely of mussels and feel perfectly well. Personal experience on the part of many testifies that the mussel is more digestible than either the oyster or the clam. The reason for this, I believe, is in the character and properties of the flesh, which by cooking is made tender and mealy, whereas in the oyster and clam it becomes very tough.

The rate of digestion and amount of nutriment absorbed from the mussel by the human system have not yet been determined. The nutritive value from a chemical standpoint is much higher than that of the oyster and about the same as that of the clam. In ratio of edible portion to refuse, the mussel compares just as favorably with the oyster and clam. With its light shell it has little waste, whereas the oyster with its thick, heavy shell has a high percentage of useless parts. From equal quantities of mussels and oysters by weight the mussels will yield between two and three times as much meat.

From the standpoint of economy, mussels rank equally high. They are widely distributed and extremely abundant, being found in the bays and estuaries of our eastern coast from North Carolina northward and on our Pacific coast from Alaska to San Francisco. They grow in great beds, often acres in extent, on the surface of mud or sand at low-tide mark. They also grow in the deeper water, where they may be dredged up by the ton. I am informed that there are places in Narragansett Bay where a man could easily obtain 50 bushels a day throughout the whole season from May to November, if he had a partner to take and dispose of the catch, and it is considered that 35 cents a bushel would be a reasonable price to ask for them under these circumstances. The mussels breed at a prolific rate, the method of reproduction being similar to that of the oyster, so that it is an easy matter to cultivate them by artificial means.

In Europe the demand for mussels as food and bait is so great that mussel culture is practiced on a large scale. Two methods of cultivation are followed, one of which may be termed the "buchot" system or French method, and the other the bed system or British method. The French method of cultivation dates back to the year 1035. It was invented by an Irishman named Walton, who was the sole survivor from a shipwreck in the Bay of Aiguillon near the village of Esnandes. He was kindly received by the French fishermen, who, up to that time, had been able to make a very scanty living from the sea. In a short time he was able by his ingenuity to give them a lasting reward by establishing the buchot method of mussel culture, which has continued to this day and at the present

time gives support to several thousand inhabitants of that region. In 1905 the village of Esnandes alone marketed 215,253 bushels of mussels, valued at $112,433. The total number of mussels cultivated on the French coast in 1905 is estimated at 425,492 bushels, valued at $222,439.

Walton's buchots, or wooden inclosures, for the rearing of mussels were made V-shaped, with the apex pointing out to the sea, the purpose of the arrangement being to protect the structure from the destructive action of the winds, waves, and ice. At the present time a buchot is made up of a row of stakes placed about 2 feet apart and interlaced with a mesh work of flexible willow or chestnut branches some 12 to 18 feet long and 2 inches in diameter at the larger end. The stakes are trunks of trees varying from 6 inches to 1 foot in diameter and from 12 to 15 feet in length, and are driven into the ground for about one-half their length. The length of a buchot at any particular place varies with the character of the bottom and the tides. In the Bay of Aiguillon they are 250 yards long and placed about 30 yards apart, running at right angles to the shore. The buchots are arranged in two divisions, one for collecting the spat, the other for the growth and fattening of the mussels. The two divisions may be composed of as many as five buchots, extending from between tide marks out into deep water. The structures out in the deep water may be as much as 3 miles from high-water mark and are exposed only at the lowest tides. They are composed merely of solitary stakes placed about 1 foot apart, which serve for collecting the spat and forming a most advantageous position for its early growth.

When about 5 months old the seed mussels are scraped off the piles and transferred to the next buchot nearer the shore, where they are fastened in parcels by means of old netting. By the time the netting has rotted away the mussels are firmly attached to the timbers by their byssal threads. When they have grown so large as to be crowded on the wicker work they are thinned out by removing the larger ones to the next higher buchots, and so on from one section to the other, each time transferring the mussels to the buchots nearer the shore. The mussels are attached by the same operation already described, but are not wrapped so carefully, since their size is such as to enable them to be more securely fastened without help of the netting. The work of transferring mussels goes on day and night whenever low tide permits.

After about one year's treatment upon these structures the mussels attain marketable size, which is between 1¾ and 2 inches in length. Before ready to be offered for sale, those that have reached the desired size are transplanted to the highest row, where although left dry twice each day they thrive well and can be easily handled when desired for market. Having become inured to exposure upon these upper rows, these mussels consequently keep longer and fresher than those from the lower rows. The poorest cultivated mussels are considered better than the best mussels grown under natural conditions.

The British method of mussel culture, briefly, is to collect young mussels from various places and transfer them to beds in favorable localities, usually in estuaries, where the water is brackish and where they are exposed at low tide, both of which conditions are supposed to favor growth and fattening. It has been estimated that the average yearly yield of an acre of such mussel beds is 108 tons, worth at least $262, which is about ten times as much as the agriculturist expects from his farm.

To summarize the qualities of the mussel, we have a shellfish as palatable as the oyster, much more nutritious, and more digestible. It contains only half as much waste as the oyster, is more abundant, is more easily cultivated in that it requires less special conditions for growth, and it is adapted for making a greater variety of food preparations. Furthermore, it is in season for the table when the oyster is out of season.

THE SMOOTH AND HORNED DOGFISHES.

The smooth and the horned dogfishes constitute another article of food that prejudice is keeping from our tables. Of these I will merely state the results of my investigations. The smooth dogfish is common on our eastern coast south of Cape Cod during the summer, and, as I have shown in a recent paper, is a most destructive enemy of the lobster. The horned dogfish during the summer months has its range north of Cape Cod, where it is exceedingly abundant, and during this season plays havoc with the herring, the mackerel, and other fishing operations. This species, although it has a general resemblance to the smooth dogfish, is easily distinguished by the two horns, one lying in front of each dorsal fin. The habits, composition, and food properties of the two species are very different.

The smooth dogfish is a bottom feeder, preying almost entirely upon crabs, lobsters, and other crustaceans. It does not run in schools, as does the horned dogfish, which goes in enormous numbers, preying upon the large schools of herring, mackerel, and upon fish caught on the trawler's line.

In composition the flesh of the smooth dogfish is free from oil, resembling most closely the cod. The horned dogfish, on the other hand, contains a large percentage of oil and in this respect most closely resembles the salmon.

From the standpoint of palatability I have good testimony that the fresh smooth dogfish is just as good as flounder, halibut, or any other of the standard food fishes. I have had the fish served several times in various ways at the mess of the Marine Biological Laboratory, at one of the private boarding houses in Woods Hole, Mass., and in a number of private homes. In all cases, whether or not the persons knew what they were eating, favorable comments were made as to the texture and flavor of the fish. Not one adverse criticism was heard. Concerning the flavor of freshly prepared horned dogfish I can not speak from

personal experience, but there is abundant testimony that it is good. The Commissioners on Fisheries and Game of Massachusetts have personally reported its palatability, the lack of odor or "strength," and the good consistency when cooked or canned. They say it closely resembles halibut. The horned dogfish has in recent years been exploited in England as a valuable cheap food. A writer in a London paper states that the Plymouth council engaged an expert cook to prepare dogfish for the table with and without sauce, and that the published opinions of those who partook were excellent as to the color, flavor, and firmness of the food. Both species are nutritious and boneless and are therefore a safe food for both the young and the aged.

The dogfishes are not only palatable in the fresh condition, but are as good as many other fishes when preserved by the standard methods. The horned dogfish being in composition most like the salmon is best adapted for canning and is considered as good as the medium grades of salmon. A packer in Petit de Grat, Cape Breton, in 1904 sent me a dozen cans of dogfish he had packed. I passed them around to my friends, who prepared the contents in different ways (fried, scalloped, creamed, etc.). In these forms the canned article was highly praised for flavor and palatability. Samples were also sent to several hotels, where the fish was served to the guests as "Japanese halibut," and was pronounced most acceptable. An establishment at Halifax has been canning large quantities and putting them on the market labeled "ocean whitefish." A firm at Charlottetown, Prince Edward Island, has been successful in selling the canned article as "sea bass."

The smooth dogfish found south of Cape Cod is preserved best by salting and drying according to the same method employed for preparing dry salt cod. The product very much resembles cod, but has the advantage of being boneless. I have had creamed salt dogfish served in the mess hall of the Marine Biological Laboratory to a score or more of persons. They all reported that they could detect little or no difference between it and the ordinary salt codfish.

The flesh of the dogfish is apparently just as digestible as that of other fishes, is palatable, nutritious, and easily preserved. The fish are so abundant and easily obtained that they are ridiculously cheap. But prejudice is barring this wholesome food from our menus. People seem more willing to starve than to eat this fish, just because it bears the name "dog." The problem now is how to put the fish on the market without an offensive label and at the same time meet the spirit and letter of our pure-food law.

The packing of both mussels and dogfish ought to become a large industry. Conditions are good for creating a market for them. They are a cheap, wholesome food for the masses and constitute a field of opportunity for the fisherman, the packer, and the merchant.

DISCUSSION.

Dr. OSCAR NORDQVIST. I think that those cheap fishes—for instance, the dogfish and such other kinds as are not used for food—would be a very good food for fish in our hatcheries. I think we could get in that way a cheap food for trout and other fishes in ponds, and I think it would be a good thing; by taking only the more appreciated kinds of fish from the sea and from lakes we disturb the balance in nature and give most chance for those poor fish to increase. And I think it would also be a very good thing for the cultivation of fish in the lakes, for instance, to take away those poor kinds of fish. I think it would be useful for the improvement of the fisheries in the lakes. So I think the more we can use those poor kinds of fish and other species of fish, the better it is for our lakes, and also of course for the sea.

Doctor GILL. I can bear testimony to the edibility of both mussels and dogfish—that is, the common dogfish (*Mustelus*), not that of the northern coast (*Squalus*). We are in the unfortunate position of having the same name for very different animals, unfortunate because of differences of habits of the other fishes of the same name. The word "mussel" in the greater part of this country in the interior is known almost entirely in connection with the species of the enormous family of Unionidæ.

Mr. WHITMAN. When you say that a mussel is a very edible mollusk, some one in the interior will say: "I have tried it. It is the toughest thing I ever attempted to eat, and worthless."

Doctor GILL. So it is; the fresh-water mussel family (Unionidæ) are really worthless; at least it requires a greater power of eating—using the teeth—than I have. But in regard to the mytilids, to which the name "mussel" was originally given, that can not be said.

With regard to the dogfish we have the same dilemma. "Dogfish" is applied in this country to a fish in the interior that is also worthless, having no relationship whatever to the fish that is known as dogfish on our eastern coast, and even the species of our eastern coast have no close relationship to each other. The so-called dogfishes of our eastern coast are as different from each other as a horse from a rhinoceros—in fact, much more so. They belong to an entirely different section of the shark branch. The only similarity is that superficial one resulting from the size and general appearance being about the same, and from the assemblage in schools being about equal. Those are the only points of similarity. They differ entirely in other features; in the dorsal fins and in the anal—one is without that fin while the other has it; the teeth are also entirely different. When we examine the interior we find the differences are really more. There is really no structural similarity, and consequently we are deceived by the similarity of the names. If we could only have different names we might get along a good deal better with the facts.

Now, perhaps you might consider this new name for the dogfish of the south—"mustel." That is not a long name; it is an euphonious name. Call the fish of the northern coast "acanth"—that is not a long name—and perhaps then we would have a solution. The fish would be just as palatable as they are now under the name "whitefish" or "herring" or anything else.

Mr. FRYER. It is quite a poetic idea that the fish culturist should turn the tables on the dogfish and feed other fish on this voracious beast. Much the same idea induced

the fishermen of England to take up the question of putting the dogfish on the market. Three years ago we had in our southern waters quite a plague of dogfish. They approached our shores in unprecedented numbers, and caused very great havoc, not only among the fish, but among the nets; even taking lobster pots and swallowing the lobsters and pots and all, with the result that in sheer desperation the fishermen armed themselves with stronger nets and set out in search of the dogfish and brought him home and put him on the market instead of putting him back again unharmed into the sea. The efforts that were made to open up the markets to this fish have resulted in a considerable amount of success. A great deal of prejudice existed in consequence of the name, the point to which reference has been made. The fish itself came to be known in the northern markets of Lancashire as Darwen salmon. It was rather a slight upon the salmon, I think. Afterwards a prize was offered by the municipality of Plymouth for a name which would be palatable, if I may use the expression, and also for a means of making the fish more palatable, and the name "flake" was pretty largely, at any rate, adopted; but this is not a satisfactory name, and I think the proposal that a euphonious title might be made up out of one of its scientific names—of one of the species of the fish, at any rate—is a very good suggestion, which might be followed up with advantage. In England I suggested the use of the word "tope," which is the Cornish name for one species of dogfish.

As regards its edibility there is no question about its being a good fish. I can vouch for that myself, and I have encouraged a great many people to eat the dogfish, especially immediately after capture. It is very much better then than if it has been kept for any length of time.

With regard to the mussel, I know that mussels are edible. I can not vouch for their quality personally so much as I can for the dogfish, because I do not like them, but there can be no question that all the virtues attributed to the mussel as an article of food are justly attributed; and there is, I should imagine, in this country a very large market for mussels, put up in some such way as these before us, at a very low price.

Reference was made to the practice in England of cultivating mussels for food purposes. I think the writer was somewhat misinformed on one or two matters, since he stated that the mussel "lays," as they are called, on which the mussels are placed for fattening purposes, are put in places where they are exposed. Now, the great object is not to expose them—not to place them above low-water mark. We find by experience that mussels that get carried up in the course of nature farthest above low-water mark develop less rapidly and get much more stunted, even when fully grown, than those which are constantly under water, even where all other conditions are similar.

Undoubtedly the brackish waters are, as in the case of the oysters, found to be more favorable for the fattening of the mussel than the very salt waters.

As regards the season: Again, I think a little slip was made, unless the habits of the mussel on this side of the Atlantic differ very much from those on the other, when it was stated that the mussel was in good season for food at the time when the oyster was in closed season or was not good for food. With us the two seasons are practically the same. The spawning season of the mussel is the same as the spawning season of the oyster. I am not sure whether I am rightly informed, but in some of your states I understand there is no closed season for oysters; but with us a closed season is established during what are held to be the most common spawning months, those being the months whose names have no letter "r" in them—after the month of April until you come to September is a closed time both for mussels and for oysters as well.

I heartily indorse from my own experience on the other side the suggestion that steps should be taken to encourage the development of fisheries for both these products; the one because it is an undoubted nuisance and for the further reason that while we are reducing the numbers of what are known as edible fish we are altering the balance of nature and leaving the dogfish unattended to. Of course in this country I need not,

I think, refer to the possibilities of the dogfish as a producer of oil and manure. I imagine that already the fish is used in those directions. The paper is limited to the question as to its use for food.

One little matter in regard to the mussels occurs to me: It is very easy indeed once an industry is established for bringing the mussels to market, to fish out natural beds, or scalps, as they are called in England; and I would recommend that if this question is taken up—the question of developing the trade by opening up the markets—the other side of the question should be dealt with at the same time and precautions taken against the possible depletion of the natural beds.

Mr. T. E. LIBBY (Maine). I just want to say a word in regard to the dogfish, for the simple reason that it is the most destructive thing to the fisheries that I know of. It is an international question, as all those familiar with it know that there is no fish along the Atlantic and Canadian shores that is so destructive to the fisheries, especially for the ground fish. As I understand from United States Fish Commissioner Bowers, there was a bill introduced in Congress appropriating $25,000 to see what could be done in regard to the dogfish—the best way to utilize it. This bill, as I understand, has got no further. There have been also bills introduced in the Massachusetts legislature, but nothing has come from that; I am pleased to state, however, that I understand, and we will no doubt hear from Professor Prince, that the Canadian government has been doing and is doing to-day something in regard to the extermination of the dogfish, not making it an article of food, but using it for the oil and as a fertilizer. I think that the dogfish as found along the southern shores is much different from the one found on the northern shores, for the reason that it has a smooth skin and the one on the northern shores is of a rough skin. I know I have seen some of those cured myself, and the northern dogfish when cured is very white at first; inside of a month, however, it will turn a yellowish cast, and I have seen efforts to put it on the market, but these were unsuccessful, because of its turning in color. The dogfish in the north has a very large liver, which of course makes it produce a very large amount of oil. For this reason the oil is all through the meat and causes it to turn.

This is a very important question, and I hope there will be some resolutions introduced in this congress encouraging the passing of some bill by the National Congress for the extermination of the dogfish.

Mr. FRYER. I do not want to become a dogfish and monopolize the conversation, but the remark Mr. Libby was good enough to make to me just now that the dogfish is used for the purpose of oil reminds me that experiments have been made in England with the eggs of the dogfish, with the result that in an immature state they have been declared to contain constituents almost exactly similar to those of hen's eggs, and to be extremely nutritious. The only thing against them is their flavor; but following that up, further experiments have shown that the eggs can be used for the production of a very high class of medicinal oil. I think that the suggestion might possibly be of practical advantage if it were made known.

Doctor GILL. What dogfish do you mean?

Mr. FRYER. The dogfish known as "rough hound." I forget the scientific name for the moment.

Doctor GILL. Yes, you mean sharks of the family of scylliorhinids; they differ very greatly from the dogfishes of our coast; they lay eggs inclosed in cases, whereas the piked dogfish or acanth, as well as the smooth dogfish, or mustel, do not hatch eggs at all externally; in fact they are viviparous.

Mr. FRYER. It is the *Squalus catulus* I am speaking of.

Doctor GILL. A scylliorhinid.

The PRESIDENT. It may be that another possible use for the eggs of the dogfish would be for the purpose of producing albumen for preparing photographic films. That only occurred to me at this moment.

Mr. FRYER. I doubt if there is very much albumen in them; they are chiefly oil.

The PRESIDENT. I am glad to be corrected. I think Mr. Atkins was about to speak.

Mr. C. G. ATKINS. I have not a great deal to say, Mr. President, but having tried the flavor of these various things that have been spoken of, I would like to say that I found personally the flavor of the dogfish was agreeable to me, and the flavor of the salt-water mussel, but that fresh-water mussel was very disagreeable.

As to Doctor Nordqvist's suggestion that we make use of the dogfish and other refuse sea fishes for feeding fish, I have been for several seasons trying to induce the fishermen to sell it for that purpose—to bring the dogfish in—but I got very few from them. I propose to carry the matter further and try to get quite a supply of them; in fact, to try them further for feeding salmonoid fishes. They are very numerous in my vicinity. Late in the summer they become a dreadful pest in all the fisheries—haddock, cod, and all those other fisheries along the coast.

Mr. JOHN J. PEW. I have tried dogfish where it has been tinned—I understood the northern dogfish. We had some tried in our office, which were sent us to see what it would be worth for mercantile purposes. We tried the flavor and to keep them in the can awhile. The color was disagreeable, not taking at all, and the flavor was not very acceptable to any of us, and we thought it was a waste of time and money to try to put them to use in our trade. We concluded the best method was to destroy them and use what we have on our coast for oil and fertilizer purposes.

Professor PRINCE. I do not want to inflict myself too much on the congress, but the subject which was brought up before us in the very excellent paper by Doctor Field has a great personal interest to me.

The first official work I ever did in fisheries was on a mussel commission in the old country, and I happened to be secretary of that commission. We went very fully into the uses of the mussel, and in our report published a number of interesting facts. One was the enormous amount of mussels annually consumed in London and other English cities as food. The amount was appalling, 10,000 tons per annum in London, if I remember correctly. Then we found that there was a very large amount used for bait by the long-line fishermen. They relied upon the mussel as their principal bait, and such a demand was there for these mussels for bait that British supplies were insufficient and mussels were imported from Holland, where mussel cultivation has been carried on to a very large extent; and I am only sorry that Doctor Hoek is not present, because he has a very thorough knowledge of what has been done in the Netherlands in the matter of mussel cultivation. The Dutch have gained wealth from their mussel beds. They export very largely to Scotland, because the Scottish beds were not large enough to supply the demand.

Personally, I have very pleasant recollection of mussels from my early days. By most people in England the mussel was considered rather a delicate morsel. I remember as a boy going to bed after a supper of mussels, and I sometimes feared the consequences, but I do not think I ever suffered harm. There is a large amount of hepatic matter in the mussel, the liver being very large indeed; but, at any rate, it is a most excellent and succulent mollusk, and it is astonishing that it has not been more utilized on this continent for the two purposes which have been mentioned, namely, bait and food.

Perhaps we ought to be cautious in recommending the use generally, without some tests being made. I may be wrong, but I have some recollection that when Captain Cook navigated the Pacific coast some of his crew went ashore and ate mussels, and I think one of the men died. That may have been due to the fact that it was not properly a mussel, but I know on some parts of the Canadian coast the mussels are not quite equal to the mussels of Europe. The matter is one that can well be looked into.

The dogfish question is one which has very seriously occupied the Canadian government. The dogfish have been for eight years or more a perfect pest on the Atlantic coast especially. They have been very numerous on the Pacific coast, and on the Pacific coast they were turned to account in the manufacture of oil, in the vicinity of Queen Charlotte Islands, but the carcasses were thrown away. In Canada the proposition was made that they should be utilized in some way or other. My own original proposition to the government was that we should adopt some method of extermination, without any idea of utilization, as Australia dealt with the rabbit pest on land. I favored methods of extermination, to get rid of the pest as soon as possible.

Another scheme, for which I am to a large extent responsible, was dogfish reduction factories for grinding up these fish into fertilizer materials. But the oil in the tissues was a very great trouble; there seemed to be too much oil to get rid of; but a very good fertilizer material was produced by three large government fertilizer works. Doctor Field, of Boston, will be able to tell us something about that. He has just visited these works. They are using a large number of these dogfish for purposes of fertilizer, and the government has spent a large sum annually on reduction works; but these factories have not done anything in regard to utilizing them as food. The three works at Shippegan, Chaleurs Bay, Canso, Nova Scotia, and Clarke's Harbor, western Nova Scotia, have all utilized the dogfish for fertilizer, and the supply of that fish was often far larger than the works could possibly handle. These enterprises encourage the destruction of the dogfish; and I believe the last reports regarding the dogfish indicate they are not so plentiful. If Mr. E. C. Whitman, of Canso, is present he might tell us something about the dogfish on the Nova Scotia coast at the present moment.

With respect to their use as food, I recommended to the Dominion Government that a bounty be given, in order to bring "ocean whitefish," as canned dogfish has been called, upon the market, but as they had to be placed upon the English markets at a very low price, in order to compete with salmon and other cheap canned fish, our Government did not see its way clear to bonus this enterprise. I requested this because I am satisfied that if the canned dogfish, properly put up, once gained any hold in the markets—the great markets of populous countries—the demand would be assured for the future. It is a most excellent food, and while Mr. Libby said—at least one of the gentlemen present told us—that the appearance of the fish deteriorated by keeping, so far as I know the dogfish which were canned in Cape Breton and Canada as an experiment had a very good appearance a long time after they had been put up. I have some of them in my office at present, and upon opening them at least a year after packing the color had not much deteriorated.

There are really a great many things to say about this question. Now, the wharves and floors of the reduction works at Canso at times were just covered with dogfish eggs nearly as large as hen's eggs, and they certainly could be turned to account. In Norway they have been used for a century or more for domestic consumption; women collect them and make puddings of them. I do not think they are good boiled or poached, but they are suitable for puddings.

There is another point that I have often referred to, in regard to this dogfish question—so serious a question for our fisheries. It is this: That the fishermen should be discouraged on all hands from simply opening the female fish full of living young and liberating them in the sea, as they have constantly done. I have been on boats when the men just did this in order to see the young dogfish swim away, which is a kind of artificial fish culture that we ought to deprecate in the strongest terms.

The PRESIDENT. Do you desire to have the discussion still continued? I wonder if any serious effort has been made to use the skin of the dogfish for leather?

Dr. GEORGE W. FIELD. The fish commission of Massachusetts had this dogfish matter placed before them for the first time about three or four years ago. They have

instituted various inquiries and experiments, and, among them, the question of the possible utilization of the skin. The chief difficulty appears to be in getting the skin off, but when it was once taken off and tanned it makes a very satisfactory leather for use on sword hilts and pocketbooks. It is a very delicate and rough leather, not unlike lizard skin, so much in vogue for certain ornamental articles.

In regard to the use of the dogfish as food, we have had some practical experience. We served the dogfish to the Biological Club, together with halibut, and students accustomed to make observations were unable to taste the difference, and claimed that it was equally good.

On the other hand, the practical packers are up against a very grave difficulty. They put this dogfish in competition with salmon, and they found very great difficulty in getting an adequate supply of the dogfish. The supply was intermittent; they would get one day more than they could handle, and then the factory would be obliged to remain idle a week, a month, or perhaps longer. So that in utilizing the dogfish it seems to me that the question of a definite supply to the factories in whatever way they are utilized is the most important one.

The Massachusetts Commission of Fisheries and Game has taken up the question of determining the valuable content of these fish. They are determining the amount of oil in the liver, in the flesh, and in the egg; how much glue there is in the skin and head and fins; whether the fins may not be utilized as they are in China and Japan for making a material for soup; whether the skins can not be utilized as leather, or some method devised by which they may be utilized more cheaply. In other words, we are trying to get a scientific basis by which the manufacturer can be in a better position to know exactly what he can do with the raw material, in order that we may say to the manufacturer, "Your process is deficient in this point or the other, and there is an opportunity for you to get better returns than you are securing at present." We are also going to attempt the consideration of the question whether there may not be devised some better method of securing a permanent supply of these dogfish to the various factories where they may be utilized, and the possibility of running a vessel about among the fishing fleet, where the dogfish may be collected and brought to the factories. We have in Massachusetts a considerable number of factories and fertilizer works where fish scrap is made, and those factories may use it to a certain extent if we can find some way by which the fishermen can be induced to bring the fish in. At present there is a tremendous prejudice against the dogfish. They are an ugly fish to handle; are a difficult fish to get off the hook if you attempt to bring them into the boat, and the only successful method is to bring them onto the edge of the boat and slap them off. The factories in one section object to handling them, whereas in Canada they are able to get all the dogfish they can handle at times at $4 or $5 a ton, and it is a question whether the fishermen in Massachusetts, who deal in the fresh fish and run the largest possible quantity of fresh fish in the least possible time to the Boston market, would care to take it up from the same point of view that the Canadian fishermen do.

There are a number of practical questions that we hope to have light on at a later time.

Mr. HATHAWAY. I will say a word on just one point that Doctor Field called to mind, in relation to an experiment made by the Fisheries Commission, to which I made reference here on Tuesday and which was conducted under my observation. One of the steamers that had been used in menhaden fishing was rigged up with an ocean overdraft, for the purpose of experimenting and seeing how the seine would work. We took the steamer at Timothy, R. I., and began operations just before sunset off 10 miles to the south of Marthas Vineyard Island. We made one haul and caught some 20 or 30 bushels of dogfish, a great variety of other fish, but none of any particular amount or value. We ran down the coast that night near to Shinnecock, Long Island, and began the next morning at daylight operating up toward Block Island. We cast a seine

some half dozen times that day, I should say, and at each haul got quite a number of dogfish, together with other fish, but no other fish in any quantity. About 2 or 3 o'clock in the afternoon, when fishing in water somewhere near 20 fathoms deep and about 10 miles to the south of Block Island, we made a big haul, and I am satisfied that that twenty-four hours' operation landed some 12 or 15 tons of smooth dogfish; so I have no doubt in the world that they can be taken in that way to great advantage. We were not able to use these fish as fertilizer, because the nearest factory to the point of operation was some 200 miles and under the conditions then existing these fish could not be run through the menhaden cookers, the knives being too small. Of course that could be easily remedied, and I understand has been remedied in the Canadian factories. If those fish could be used or had any value at all, I have no doubt in the world that in the deep-sea trawl fishing along the coast from Shinnecock to Sandy Hook, where my experience lay, dogfish could be caught in quantities and sufficient to make it a commercial value to the fishermen.

As to the edibility of the dogfish: They have been eaten for years and years along part of our southern coast, particularly in the lower Chesapeake Bay, from which I originally came; and it is said that they have been used in connection with crab meat, which is so abundantly put up.

The mussel is very abundant along the coast, and I two years ago purchased from a fisherman, to be used for fertilizer—for manure—a thousand bushels for $50. He landed them on the wharf at the farm lot in Little Egg Harbor, near New Gretna, New Jersey. Now, those mussels were opened up by this fisherman, giving him sufficient wages to live, for 5 cents a bushel. All along the coast, from Cape May to the Maine coast, they are very abundant. They are not very abundant below Cape May.

Mr. WHITMAN. Reference has been made to government dogfish reduction works at Canso, Nova Scotia, and as I have just come from there it may be interesting for you to know that those works are now taking in all they can handle each day. The works have a capacity of 25 tons of dogfish a day, and if they had a capacity of 500 tons a day there would be no trouble to supply them. Just at this season the dogfish are very abundant, and I recently saw one vessel bring in 50 tons, which would of course supply the works for two days. But they are making no use of them except to extract the oil and convert the residue into fertilizer. This has been going on for the past three years, since the Canadian government decided upon this method of dealing with the dogfish pest. It is not a commercial success. The government always pays out more money than it receives, but that is chiefly because the operating season is so short. The works operate only some two months of the year, and the fishermen will not catch dogfish at $4 a ton if they can get more profitable fishing to do. It is only when the dogfish become so plentiful that they can not carry on regular fishing for food fish that the fishermen turn their attention to the dogfish.

The oil is of superior quality, and both the oil and the fertilizer find ready sale. The fertilizer up to this time has been marketed in New York at $35 a ton. The oil sells for 30 cents a gallon. Experiments are now being made to see if other products can be taken from this fish, such as glue and isinglass; and if the skins can be used as Mr. Field has suggested, that will be good, but up to this time they have been treated only for the oil and fertilizer.

The PRESIDENT. Shall we close the discussion?

Dr. GEORGE W. FIELD. As Professor Prince has said, we visited last month three factories, to which Mr. Whitman has referred, and we got statements in regard to the amount of dogfish they had destroyed at two of these works. We made a rough estimate, and we figured that those two factories had destroyed about one-fourth of what the entire Massachusetts fleet catch in one year. We figure the Massachusetts catch at about 27,000,000 dogfish a year; and we found that about 7,000,000 dogfish were de-

stroyed, i. e., turned into fish scrap, at these two factories during the time they were running.

Mr. WHITMAN. It might be of interest for you to know that the steam trawler that was brought over from England to operate on our Nova Scotia coast in one hour recently filled her trawl net so full with dogfish that it parted the lines, and carried the net away. The captain estimated more than 15 tons of dogfish in the net. He says that he usually avoids the places where dogfish are. He knows them by the oil on the surface of the water. But this time the net was cast in the wrong place and in a few minutes it had filled so full that the weight carried the net away.

Doctor GILL. I think that Doctor Field of Woods Hole labors under some misapprehension as to the clam. He remarked, if I understood him rightly, that the clam was not esteemed in England. They have no clams, in our sense of the word, in England. The family of venerids is represented by only two small species of no economic value, their place being taken economically by the cockles or cardiids. By a curious coincidence, the name "clam" is in very little use in England, and what they call a clam is not like our hard clam at all. It is a very interesting fact that we derive the name clam from England, but we apply it in a very different way from what it is applied in England. Of course, I can not go into the full history. Suffice it to say that the word "clam" in England is mostly applied to the piddock—that is, to a species of the family of pholadids.

Dr. IRVING A. FIELD. In reply to Doctor Gill's criticism, I want to say that it is not from personal experience that I speak about the clam of Europe; that is a quotation from Ganong's Economic Molluska of Acadia, in which he states that the soft-shell clam occurs in Europe, but is not used. He calls it the soft-shell clam.

In regard to the poison mussel: There are cases of mussel poisoning on record. There are also cases of poisoning from clams, from lobsters, from crabs, and other animals in that group. I wish to state, however, that there are no cases on record of poison from mussels that were collected from what might be called pure water, in good circulation. The most notable cases of mussel poisoning on record are those which occurred at Wilhelmshaven, Germany, in the early eighties, and in these cases it was found that the mussels came from stagnant water. These mussels, which were very poisonous, when placed in free-circulating water became harmless in about two weeks. On the other hand good mussels placed in the impure water became poisonous. We may say, therefore, that poisonous mussels come from poisonous water. These results were obtained by Virchow and also by Wolff in 1886.

Doctor GILL. You have found persons pretty generally prejudiced against mussels?

Dr. IRVING A. FIELD. Yes; for that reason.

Then as to the season for mussels, I wish to say again that I was right when I said that the mussel is in season when the oyster is out of season, for the mussel is the very best to eat during the breeding season, or just prior to the breeding season. After the breeding season the mantles become very thin and there is very little meat to the mussel at all.

I stated in my paper that they breed at a prolific rate. I have not been able to locate the center of the reproductive gland. In fact the whole animal is a reproductive gland at the height of the breeding season. If you take a mussel in June or July you will find the reproductive organs covering the floor of the body, filling the mantles full and extending over the liver, so that the whole mussel appears to be a great reproductive gland. Eggs, of course, are very nutritious, and it is at this period we find the mussel containing about 18 per cent of protein. In September and October, or the latter part of August, September and October, when the sexual products are liberated, mussels lose probably two-thirds or three-fourths of their weight, become very thin and shrivel up, so that when cooked they are no larger than the end of one's little finger.

Now, coming to the dogfish, I think it was Mr. Libby who said there was trouble in dry-salting northern dogfish, which at first are white and nice but later become brownish

and very disagreeable in appearance. I have had that experience myself. It becomes the most nasty-looking stuff, covered with a brown, gelatinous substance; but I have found that if you keep the dogfish in a brine they will remain white for an indefinite period. I have some two years old in good condition. You can take them out of the brine and soak them for a few hours before cooking. If put on the market in brine they can be made a good food product, and persons can keep them at their homes a week or two before they will turn brown.

The dogfish may be of economic value from the standpoint of the production of gelatine. There is a very high percentage of gelatine in the flesh of dogfish, and when extracted it comes out beautifully clear and white, and apparently needs no refinement, the only objection to it being that it has a fishy flavor. I think possibly Doctor Alsberg, the chemist at Woods Hole, will be able to tell us a great deal about this in a short time.

Doctor GILL. That is quite right about the clams along this coast, south of Cape Cod. The common or hard clam is the *Venus mercenaria*, a representative of the family of venerids; the clam along the north coast, or soft clam, is the *Mya arenaria*, a species of the family of myids.

THE WHOLESOMENESS OF OYSTERS AS FOOD

By Henry C. Rowe

President Connecticut Oyster Growers' Association and New York and New England Oyster Shippers' Association, New Haven, Conn.

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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By HENRY C. ROWE,

President Connecticut Oyster Growers' Association and New York and New England Oyster Shippers' Association, New Haven, Conn.

The necessity for the conservation of the resources of the nation has recently been brought emphatically before the public. The increase of our population in the past and its greater prospective increase emphasize the importance of not only conserving our resources but of encouraging the creation and development of productive industries. During the past thirty-five years such an industry has been created and developed in the propagation and growing of oysters. This industry produces already annually a great amount of valuable food, its yearly value in the states of Rhode Island, Connecticut, New York, New Jersey, Virginia, and California amounting to $9,316,252. Other states are developing the industry, but these named have taken the lead. A large population is supported directly by it, and perhaps still more by contributory industries.

During the same period, while a large portion of our forests have been destroyed, the oyster farmers and cultivators have purchased from the different States permission to cultivate the hitherto barren ground covered by the waters of our bays and sounds to a depth of 25, 50, or even 100 feet, and have, by expensive and hazardous experiments, caused this unproductive ground to yield annually 10,235,566 bushels of oysters, a valuable and nutritious food, and furnished employment and livelihood to thousands.

While the United States and the various states have at public expense propagated millions of swimming fish, to be caught by those who are engaged in these fisheries, the oyster grower and planter has at his own cost propagated his own crops and worked out his own results by patient labor, costly experiments, and large investment. Instead of having his crops produced and protected for him, as has been done for the fishers of swimming fish, he has paid large sums to the states for the use of the ground on which he might create and prosecute this industry. In Connecticut, for example, the oyster growers have paid to the state

and towns over $260,000 for the franchises permitting them to cultivate oysters and in taxes upon these franchises, and have paid many hundreds of thousands more in taxes upon the steamers, shops, wharves, and other appurtenances of a great industry. In Rhode Island, besides the general benefit to the prosperity of the state resulting from a great productive industry—which is, of course, the principal consideration—the oyster growers pay annually to the state a very large sum in rentals for oyster grounds. The income to the state from this source in 1907 was $96,000, and it is estimated that in 1908 it will be more than $100,000.

The oyster industry has been created and developed notwithstanding many and great obstacles. Great storms have swept away the results of the outlay of millions of dollars in experiments and planting. The natural enemies of the oyster, especially the starfish and the drill, have destroyed millions of dollars worth of the product, and the oyster farmers have expended millions more in catching and destroying these enemies. They have suffered great losses from many causes and have encountered and defeated unnumbered difficulties, perils, and vicissitudes. Hostile legislation and litigation have been overcome. The lawless have sought to find flaws in the titles, so as to reap the fruits of the labor of others. Demagogues have appealed to the underlying anarchistic or poacher sentiment, which exists among some classes of voters.

One of the most trying experiences which the oyster grower has been called upon to meet is the recent storm of public notion in decrying oysters as an unwholesome food. People have been accustomed to regard oysters as a nutritious and especially as a digestible food, and one which is most welcome to the palate of the epicure. It is but natural that they should desire to know whether there is any foundation for the sensational assertions that have been made against oysters. In recent years many kinds of food, perhaps a majority of all the kinds, have been claimed to be objectionable in one way or another. They have been found adulterated, in insanitary environment, or exposed to contamination by the germs which are blown about in the dust of the streets. Milk has been found to be swarming with the bacilli of typhoid, diphtheria, and tuberculosis, and water with typhoid and malarial germs. These have caused hundreds of epidemics of typhoid fever and other diseases. Flies and mosquitoes have conveyed in multitudes of cases typhoid and malarial infection. Among them all probably no article of food has been attacked in so sensational a way, with so small reason or ascertained fact, as oysters. Some so-called scientific writers have attacked them because the subject was novel and sensational, although previous scientific research had proved the oyster to be a most nutritious, easily digested, and valuable food. A novelty is a welcome subject for a magazine or newspaper article.

It has been claimed, perhaps truly, that there were formerly a few places where oysters were planted or floated that might be considered insanitary. While 1 bushel in 100,000 might be so situated, the other 99,999 are grown in the deep pure water of the great bays and sounds. In those cases where there was suspected danger of insanitary effects, or even criticism, the great oyster-shipping firms voluntarily discontinued floating and shoring oysters, and the other shippers have been required by law to discontinue doing so. It is now forbidden to market any oysters from places that are not approved by the health authorities. But notwithstanding these facts, certain writers and reporters have continued to work this profitable vein of sensationalism. There was no definite statement that any typhoid fever germ had ever been found in an oyster, but there was a mass of insinuation and innuendo which wantonly injured a great industry.

It is contrary to public policy that a food such as oysters, which are noted for their great palatability, easiness of digestion, and high food value, should be lightly thrown aside without any evidence worthy of being called such. Every thoughtful man is compelled often to recognize the prevalence of popular errors. Many of the accepted theories and beliefs of twenty years ago have been disproved by facts later ascertained, and some were consigned to the scrap heap within a tenth part of that period. Among these subjects the theories of the causes of disease and how to avoid them are no exception, and have had a history of many radical changes, in which imagination and notion have by no means been absent. Hence reason dictates that we should be slow to accept theories, even of thinking men, until clearly proved, and far more, that our opinions ought not to be influenced in the least degree by the waves of popular notion which are promulgated by the sensational press to supply the morbid hunger of the unthinking multitude for novelty and excitement. The president of Columbia University has aptly said:

> The daily press, with its hectic headlines and its guillotine-like opinions, assists us to form the habit of acting and judging without thinking. * * * A distorted and inaccurate account of some important happening will serve to fix our permanent attitude toward a man or an event, and we may never know how hopelessly inadequate or erroneous the grounds for that attitude are.

Careful observation and examination lead to the conclusion that the recent attacks upon the healthfulness of oysters have little or no foundation in fact.

The most prominent case in which positive statements were made that typhoid fever was contracted through the use of oysters was published in a New Jersey newspaper within the past year and copied from that newspaper throughout much of the United States and Canada. These statements were thus placed before millions of readers. It was stated that two persons,

Ferdinand Bendt and his wife, Rosa Bendt, of Newark, N. J., had died from typhoid fever, the result of eating infected oysters. On investigation it was found that the official report of the board of contagious diseases shows that neither of the persons had eaten oysters, but that they had eaten other foods which are sometimes infected by typhoid fever. Also the death certificates showed that one of them did not die of typhoid fever, but of cerebro-spinal fever.

Before the original article was printed, the attention of the reporter was called to the fact that the deceased had not eaten oysters, but he ignored the information and printed the sensational report regardless of truth. Later the newspaper was asked to correct the misstatement, and replied that a correction would be printed if the space required to do it was paid for.

In another case to which much prominence was given, a young physician gave to an evening paper an item in which it was stated that a certain young lady, a teacher in a public school, was very ill with a malignant case of typhoid, incurred by eating oysters. A careful investigation of the facts proved that she was but slightly ill, and not with typhoid fever; in fact, the doctor was unable to diagnose her case, but he half jestingly asked her one day if she had been eating oysters, and he was informed that the family had received some sent by a friend. He overlooked the fact, however, that she had not eaten any of them, while her mother and brother had done so and were not ill. A written statement signed by the mother and nurse of the patient established these facts. The result of the newspaper item was to give this young physician some free advertising, as having brought the young lady through a course of typhoid fever, and incidentally to instill an unfounded prejudice against oysters in the minds of thousands of readers of the newspaper.

Another illustration is afforded by the action of the health officers of Poquonnock, in Connecticut, where, several years ago, an epidemic of scarlet fever was attributed to the culture of oysters within the limits of the town. The health officers went so far as to require the destruction of the industry in their waters, for which the state of Connecticut some years later paid damages. At the present time no one believes that the oysters had anything to do with the epidemic which was then charged to them.

Many other instances can be cited in which sensational reports have been published with very little, if any, evidence underlying them. In many cases the motive for these reports is clearly that the reporter is paid for the "scoop," as he calls it, and it is an unfortunate fact that there are some newspapers that will accept and publish any sensation which is not actionable. Also it may possibly sometimes occur that a physician or health officer will carelessly allow himself to make public a suspicion or surmise which does great injustice, though it may perhaps enhance his own importance in the public eye.

Then, too, there is an incentive to sensational reports about oysters, because the claim that they cause disease is a novelty. Milk has been found to be the cause of typhoid fever in so many thousands of cases that such reports no longer secure so much attention in sensational journalism as does one alleged or suspected case that is attributed to oysters.

I would not be understood to say anything against the general and almost universal use of milk as a food. The most that we would claim is that care should be taken to keep milk free from contamination, but there is not one-thousandth part as much evidence to cause us to fear the contamination of oysters with disease germs as there is of milk; in fact, recently a great variety of foods have been declared dangerous to health. According to "The Jungle" and the investigations resulting, the methods under which meat was prepared for the market were revolting. Milk has been found to be swarming with the bacilli of tuberculosis, typhoid fever, and diphtheria. Flies have been proved to carry the germs of typhoid fever and other diseases, and deposit them upon every kind of food upon which they alight. Analysis has disclosed harmful adulterations in many of the prepared foods and drinks. Public and private supplies of drinking water have in many instances caused devastating epidemics of typhoid fever, and the bacilli have been found in vast quantities not only in the water but in milk which had come in contact with cans washed in the water.

Among these many dangers from food and drink, it becomes necessary to discriminate between those foods which are known to be dangerous to health and those to which mere suspicion is attached. We must eat and drink; therefore we need to know in what foods disease germs have actually been found, and, on the other hand, those to which unproved suspicion has attached.

To those who have read the sensational statements against oysters, it will be a surprise to know that although many expert bacteriologists have searched diligently for typhoid bacilli in oysters, I have not been able to learn of one single authenticated case in which bacilli have been found in oysters in the United States, except when placed there for purpose of experiment; while the germs have been found in milk and water in innumerable instances and are known to multiply in these media to an extent beyond arithmetical expression and beyond the comprehension of human intelligence.

Another assertion that has been recklessly made about oysters concerns the use of preservatives. When oysters are handled as they are under modern methods—caught by steamers on one day, opened the next and, after being thoroughly chilled with ice, shipped into the country, there is not the slightest need or occasion for the use of chemical preservatives. I can say without hesitation that not an ounce of any preservative excepting ice has ever been used

in oysters shipped by my firm during an experience of forty years, and I have no doubt that other reputable firms are equally particular. The fact that 99.9 per cent of the oysters now marketed are taken from deep salt water causes them to be incomparably more free from disease germs of all kinds than is true of most of our ordinary foods, which come in contact, while exposed for sale, with the air and dust of the streets, in which disease germs abound.

Hundreds of instances could be cited of the amazing multiplication of the typhoid-fever germ in drinking water, but one will suffice as an illustration: A few years ago there was a single case of typhoid fever in a house that was situated on a slope which led, a considerable distance away, to one of the water supplies of the city of New Haven. A little drainage proceeding from this house ran over the frozen ground of winter to the lake. There the germs multiplied to such stupendous extent as to communicate the disease to more than 500 of those who drank the water in that section of the city, with over 50 deaths.

The following statement from the Medical Journal gives a recent authority ("Milk and Its Relations to Public Health," Bulletin No. 41, Hygienic Laboratory, Public Health and Marine-Hospital Service) upon the subject of milk, which is so generally and freely used, as follows:

> The conviction that is forced upon the reader of these startling reports by men who are writing, not to cause a sensation but to state facts, is that the "jungle" as a disseminator of disease is as nothing compared with the dairy. The thought of eating meat prepared under the conditions that prevailed at one time in Chicago and that still prevail in other cities, whence emanated such pharasaical condemnation of the Chicago methods, may not be pleasant, but the actual danger to health from this cause is almost negligible when we consider the morbidity and the mortality directly traceable to milk from the ordinary farm or even from many a so-called model dairy. Dr. John W. Trank, of the Marine-Hospital Service, gives in this bulletin a tabulated report of 500 epidemics of typhoid fever, scarlet fever, and diphtheria caused by contaminated milk. These epidemics were only a few of those which have been reported and are accessible in the literature, and how many there may have been in the past which were never reported or the origin of which was never found can only be imagined. In addition to this, a report by Doctor Anderson shows the part which infected milk plays in the dissemination of tuberculosis. He examined 272 samples of the market milk of Washington, supplied by 104 dairies, and found that 6.72 per cent of the samples contained virulent tubercle bacilli, and of the dairies there were 11 per cent the milk from which contained these micro-organisms. One institution for children was found to be feeding its inmates on milk which caused tuberculosis in guinea pigs. Doctor Mahler's investigation led him to the conclusion that probably 25 per cent of the cows supplying milk to the District of Columbia are tuberculous.

Let us compare the preceding with the statement in the bulletin of the Chicago Board of Health, dated November 23, 1907, that the bacteriologists of the board of health of the city of Chicago examined samples of all the oysters shipped from the various sources to Chicago during the preceding month and found all of them absolutely free from any contamination or danger to health.

In addition to the preceding comparison, no bacilli of tuberculosis, diphtheria, or any other disease have been found in oysters, and there has been no case, even of circumstantial evidence, showing that cooked oysters have caused typhoid fever, or any other disease, except possibly ptomaine poisoning, which may occur in any one of hundreds of foods if proper care is not exercised. It is conceded, however, that proper cooking will destroy bacilli in oysters if any do exist.

The limits of this paper forbid the introduction of a vast amount of available evidence along these lines, but it is clear that compared with the conclusive proof of the occasional danger in the use of milk and water, the evidence against the wholesomeness of oysters is so trifling as to be negligible. Let me repeat that I do not urge or imply the disuse of milk and water, but merely use a comparison with which we are all familiar, and I believe it is clear that so long as milk and water are freely and universally partaken of it is unreasonable to harbor the least prejudice against oysters as a food.

EFFECTS OF MENHADEN FISHING UPON THE SUPPLY OF MENHADEN AND OF THE FISHES THAT PREY UPON THEM

By Walter E. Hathaway

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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EFFECTS OF MENHADEN FISHING UPON THE SUPPLY OF MENHADEN AND OF THE FISHES THAT PREY UPON THEM.

By WALTER E. HATHAWAY.

The object of this essay is to determine impartially, as nearly as possible from the facts and information obtainable, the effects of fishing, with modern and improved apparatus, on surface-swimming fishes and on such fish as prey upon them. This inquiry, therefore, will naturally proceed from two standpoints: First, the effect directly on the surface-swimming fishes, and, second, the effect on such predatory fishes as feed upon those of the former class.

While it is the habit of nearly all of the migratory fishes that inhabit the waters of the middle and north Atlantic coasts of the United States during the spring, summer, and fall months of the year, such as bluefish, weakfish (which south of the Delaware Bay are known by the general name of "trout" and north and east of Montauk Point as "squeteague"), drum, bonito, mackerel, and menhaden, while on passage, to travel in schools and largely on or near the surface of the waters, these all, except the mackerel and the menhaden, disperse when reaching their feeding grounds and appear infrequently on the surface thereafter. While the mackerel is at times during the entire summer and fall a surface-swimming fish, and is also found in schools, it is more generally found in small and scattered numbers and often deep under the surface.

Therefore for the purpose of this inquiry the menhaden alone will be considered, as of all the fishes that inhabit these waters it alone, strictly speaking, is a surface-swimming fish, and invariably swims in schools. However, conditions of the weather, especially the temperature of the water, and the presence of enemies, whether man or fish, have great influence upon the actions of these fish. They have often been known to be in certain waters in great abundance for days, weeks, and even months, but in such scattered numbers that they could not be successfully taken in purse nets, and at such times appearing on the surface only at intervals, longer or shorter, under the most pleasant and favorable weather conditions.

No notice will here be taken of such fish as shad, herring, and alewives, which seek the shores only to spawn and not for feeding grounds. The principle governing the catching of them is entirely different from that of catching the menhaden, which come to the shores to feed and not to spawn.

HABITS OF THE MENHADEN.

It is true that the menhaden do spawn on the Atlantic coast of the United States, but only in limited numbers. Spent fish have been found all along the coast from Maine to Florida, but never on their passage north. Such fish have been examined in Maine as early as July 15 and on the Atlantic coast of Florida as late as December 15. The small fish of that season's spawning are found all along the coast south of Sandy Hook, for the most part during the months of August and September. They have rarely been seen north and east of Long Island. During the first week in September, 1906, the writer saw several schools of very small menhaden, from 1½ inches to 2 inches long, in the harbor of Vineyard Haven. Old fishermen, whose observation of those waters had extended over long periods, in one case fifty years, stated that they had never seen them there before.

It is unquestionably a fact, although up to this time not demonstrable from actual observation and investigation, that the menhaden spawns principally in the warm waters south of the United States, probably in the Caribbean Sea, and mainly during the months of January, February, and March. The writer examined many hundreds of menhaden caught from the 20th of November to the 10th of December, 1906, between Cape Lookout and Georgetown, S. C., and without a single exception they were fish due to spawn in from thirty to sixty days; those fish were moving south at a rate of from 20 to 50 miles per day.

Menhaden are also found in large quantities and have been and are being taken for commercial purposes in the Gulf of Mexico, but these are slightly different in appearance and habits from the menhaden found in the Atlantic Ocean, being a little heavier in body in proportion to length and less active. It is believed that they do not migrate into the Atlantic, but remain about the Gulf coasts of the United States and Mexico.

Many different theories have been advanced and maintained as to the spawning habits of the menhaden and also as to their habitat during the winter and early spring months; but it is believed by the writer, from a very careful personal observation of these fish for the past twenty years and over the entire eastern coast of the United States from Maine to Florida, that the statements herein made are, as nearly as present knowledge of the subject will justify, correct and accurate. This statement, however, is made with due modesty; for upon one occasion when he asked an old fisherman who had taken menhaden for fifty years, and all the way from Casco Bay, in Maine, to Port Arthur, Tex., "Captain, what do you know about menhaden?" the answer, very emphatically given, was, "Not a damn thing."

It is, however, a clearly established fact that the menhaden seek this coast for food and not to spawn.

The menhaden, scientifically known as *Brevoortia tyrannus*, has many local names along the coast—in North Carolina, "fat backs;" in Virginia, "old wives;" in New Jersey and New York, "moss bunkers;" and generally in New England, "pogies."

As is common with all migratory fish, the oldest and strongest go farther afield, in the case of the menhaden farther north. Therefore the size of the fish found on various parts of the coast differs; the average size of the fish caught on the principal grounds being, in Maine, about 12 inches; in Long Island Sound and adjacent waters, about 10 inches; on the "Jersey beach" and in Delaware Bay, about 9 inches; in Chesapeake Bay, about 8 inches, and south of Cape Hatteras, 6 to 7 inches.

On their journey north, which begins usually in March, the fish do not follow the coast, but travel some distance out at sea, the schools "striking in" near their usual feeding grounds. Returning, which migration begins from New England waters early in September, those about and north of Cape Cod usually disappear first from Nantucket Shoals and the waters adjacent to No-Man's Land. From Cape Cod to Sandy Hook they sometimes follow the ocean side of Long Island and the New Jersey coast as far as Cape May, sometimes disappearing off Montauk Point. Those spending the summer on the "Jersey beach" and south of the Delaware usually follow the coast to Cape Hatteras and often even to the Savannah River. Therefore in the late fall and early winter large fish are often taken as far south as Charleston.

Having thus with reasonable certainty established the nature and habits of the menhaden, the next and most important part of our inquiry is, What effect has the taking of them by man had upon the supply and quantity, and also upon their movements?

THE MENHADEN FISHERY.

Menhaden have been taken along the Atlantic coast since the first settling of the country by white men. Indeed, it is believed that the Indians were acquainted with the use of fish to enrich the ground. Up to about 1870 they were taken in small quantities only, in the smaller bays and inlets and in the mouths of the rivers, generally in shallow water, with very simple devices, and they were used mainly for fertilizer or manure, but in part for food. For many years they have been used in a small way for food by the negroes and poorer whites along the southern coast country. Properly cleaned and salted they can be eaten with relish in default of a better fish. The fresh roe, fried, is not bad food and is sometimes eaten in the coastal country south of Cape Hatteras, when the fish are taken on their way south in the months of November and December. The whole fish, either applied directly to the land or composted with barnyard manure or woods litter, has been used as a fertilizer all along the Atlantic coast of the United States since early colonial times.

But this was a wasteful and ultimately injurious process if continuously applied, because the oil in the fish was not only lost but in time seriously damaged the soil, causing it to become stiff, gummy, and sour. The first commercial use of the oil was due to the ingenuity of a woman, about the year 1850. The process of extracting the oil was at first very crude, and the remainder of the fish, the "scrap," was for the most part thrown away. Both the oil and the "scrap" are now manipulated with improved and expensive machinery and apparatus.

At the present time there are about 30 factories with 70 steamers engaged in the business of taking menhaden and making them into "scrap" and oil. The average annual catch is about 600,000,000 fish, producing some 70,000 tons of "scrap" and 35,000 barrels of oil. The industry has been on its present basis since about 1885. During these twenty-three years the annual catches have varied greatly, from about 250,000,000 in 1892 to over 1,000,000,000 in 1903, but there has been little or no variance in the average for a period of years. The catch per steamer per season has also greatly varied, owing to locality of operations and the proverbial luck of fishermen, from 3,000,000 or 4,000,000 to 23,000,000. The season of 1906 was a poor one; last season, 1907, was poorer, the total catch not being over 350,000,000. This season up to the date of this writing, September 7, has been one of the best ever known, and prospects are for a catch of at least 800,000,000. These facts seem to demonstrate clearly that so far as abundance is concerned, taking an average period of years, there has been no diminution of the quantity. Weather conditions, particularly the temperature of the water, govern the movements of menhaden greatly. This has been an ideal season, the weather along the coast from Hatteras to Montauk having been uncommonly mild and pleasant; during the previous two seasons of 1906 and 1907, on the contrary, these conditions were exceedingly unfavorable.

EFFECTS OF THE FISHERY UPON MOVEMENTS AND NUMBERS OF MENHADEN.

What effect has this fishing on the movements of the fish? Generally, the constant operation of modern seines and steamers at, in, and about the mouths of the narrower estuaries of the ocean have a tendency to keep the fish out of such waters. To illustrate, the daily operation during the early months of this season of some 30 steamers about the mouth of the Chesapeake Bay undoubtedly kept fish that had started for that water away, and turned them both up and down the adjacent parts of the Atlantic coast, and notwithstanding the general abundance of these fish this year they have been uncommonly scarce in the upper part of the Chesapeake Bay and the rivers emptying into it. The fishing on the present scale has kept the fish out of the smaller bays, inlets, and rivers in the immediate neighborhood of large seining operations in the near-by ocean. Also, excessive or reckless fishing, even when on very large schools, and especially when the fish are on their migratory move-

ments, will often cause them to scatter, become wild, and even disappear altogether.

To sum up, the annual taking of some 600,000,000 of menhaden per season for the past twenty-three years has to no perceptible extent or in any perceivable amount diminished the average number in the ocean and its great estuaries; but it has lessened the quantity in some of the smaller water areas adjacent to large fishing operations, in some cases almost to extinction. The self-evident lesson to be learned by the commercial menhaden fishermen—and the nature of this fish is such that no one else has even a remote interest in it—is that in the future these fish will be largely taken in the ocean with larger and faster steamers and more improved appliances.

EFFECTS OF THE MENHADEN FISHERY UPON PREDATORY FISHES.

There have been no menhaden, only a few excepted, north of Cape Cod since 1898. This is due in part, no doubt, to the increased destructiveness, in those waters, of dogfish, but scientists believe it to be due principally to the temperature of the water. Even the large and vigorous menhaden do not go to or remain in water cooler than 60°. It has been contended that these northern fish were all caught up by the steamers. Even were this true, for the last season in which there was any menhaden fishing in Maine, 1898, why have they not returned? There have been comparatively no menhaden taken north of Cape Cod for ten years, and they have been abundant south of the Cape several years since 1898, notably in 1903, when over 1,000,000,000 were taken.

It is distinctly the opinion of this writer, following the dictum of Colonel McDonald, that no migratory fish can be materially diminished, much less destroyed, by any appliances that the brain and ingenuity of man have yet devised, when not taken on their regular spawning grounds. The herring and mackerel fisheries, both in this country and in Europe, satisfactorily demonstrate this truth.

Lastly, let us consider what effect the taking of menhaden by man has on the fish that prey upon it. Nature's evident purpose in producing the menhaden was to supply food directly to fishes, and indirectly to man on account of its value for fertilizing purposes. It is, perhaps, the most promiscuously prolific of all fishes.

Almost all predaceous fish prey upon menhaden. In the order of their destructiveness, estimating the entire Atlantic coast of the United States, I would name the shark, the bluefish, the dogfish, the weakfish or squeteague, the porpoise, and the bonito. The shark is their principal enemy south of the Chesapeake. The writer opened one shark taken off the mouth of the Cape Fear River, in North Carolina, and actually counted 352 well-defined menhaden taken from its stomach, at least half of them entirely whole; and he has seen thousands of them preying on schools of menhaden in the same waters. Many

sharks are caught in the menhaden nets, as many as 275 having been taken by one steamer in one day. In the beginning of the menhaden fishery at the mouth of Delaware Bay sharks were very numerous in those waters, much more so than they are now, and it is believed that the constant taking of them in menhaden nets has caused this decrease. There can be no doubt that whenever any fish that produces its young in such small numbers can be taken in any given water in large quantities its practical extinction is only a matter of persistence and reasonable time; and the writer, who has seen 7 tons of dogfish taken at one lifting of a deep-sea trawl, in experiments conducted by The Fisheries Company to the south of Block Island in September, 1907, is entirely satisfied that that pest of the North Atlantic coast can practically be exterminated.

The bluefish is so erratic in its nature and habits and of such uncertain and irregular habitat that little can be said about it with any positiveness. It unquestionably eats and destroys large quantities of menhaden, especially north of Delaware Bay, but as it is never caught in quantities in seines, and feeds on all other varieties of fish smaller than itself, it is not believed by the best authorities that the taking of menhaden by man has any effect whatever on bluefish.

The only food fish of any particular value, other than the bluefish, that feeds to any extent on the menhaden is the weakfish, or squeteague. There is quite an extensively entertained opinion in certain places along the coast, especially in New Jersey and southern Massachusetts, that the constant taking of menhaden by the steamers materially diminishes the quantity of weakfish and squeteague for the anglers—for the reason that the food being taken the weakfish and squeteague seek other waters more profitably supplied. If these people would only just for a moment realize that only the largest weakfish feed on menhaden, those under 3 pounds rarely ever eating any but very small menhaden, and that the large weakfish is a sea fish and seldom frequents the small bays and inlets, they would know how silly this belief is. It is a fact that the catch of weakfish in the pounds on the New Jersey coast and by the New York fishing smacks has increased year by year, notwithstanding the large numbers of menhaden annually taken from the same waters. It can be asserted with entire confidence that the taking of menhaden by man has had absolutely no effect on the abundance or movements of weakfish during the existence of the menhaden industry.

G. Brown Goode, in his "History of the American Menhaden," says:

> Is it too much, then, to multiply the three hundred millions of millions of menhaden probably consumed by the full-grown bluefish alone on the coast of New England in the summer months by ten? This would allow three thousand millions of millions of menhaden, old and young, annually destroyed in the waters of the United States, in comparison with which the number annually taken by men is perfectly insignificant. This estimate will seem extravagant at first sight, but I believe that it will be found a very moderate one by any who may take the pains to investigate the question for themselves.

This opinion has been approved and concurred in by Professor Baird, Colonel McDonald, and Dr. Hugh M. Smith, than whom there are no higher authorities on the subject to be found. Assuming that it is even approximately correct, can any intelligent person, even with the greatest stretch of fancy, imagine that the comparatively few menhaden taken by man can in any way affect the fish that prey on the menhaden, which have for thousands of years been taking thousands of menhaden for every one that man has taken during a few years?

CONCLUSION.

There can be no question but that the fishing by man has in no way diminished the quantity of menhaden in the ocean, the only effect having been to retard or change the movements of small lots, in and about specially located bodies of water. Nor has it had the minutest effect on the predaceous fish that feed upon them, except the possible decreasing of sharks in the waters north of Cape Charles, and this may be due to other causes than taking them in nets with menhaden. Extensive investigations made under the authority of Dr. Hugh M. Smith, of the United States Bureau of Fisheries, have clearly demonstrated the fact that food fish are seldom taken in the menhaden nets and never in any quantities. The writer, first and last, has seen perhaps 100,000,000 menhaden taken, among all of which there were not 1,000 food fish of any kind.

When we consider the illimitable vastness of the ocean's extent; the marvelous fecundity of the menhaden, one female producing sometimes 18,000 eggs; the incalculable numbers there must be in all the waters, as many as 500,000 having been taken from a space of less than an acre's surface; we can inevitably reach but one conclusion: That they were designed in the all wise provisions of nature for man's use and benefit, and it behooves man, with such skill as his wisdom and ingenuity can devise, to take them and use them, believing that for every one he can take each year probably tens of thousands die and are destroyed by other agencies.

DISCUSSION.

The PRESIDENT. The menhaden always provokes discussion. I know the Bureau of Fisheries has for twenty years been making observations at Woods Hole on the breeding habits in the neighborhood of Buzzards Bay and Vineyard Sound. I dare say that Doctor Smith will give information in regard to the results of the observations made upon the breeding habits of the menhaden in the north.

Dr. HUGH M. SMITH (secretary-general). Mr. President and ladies and gentlemen, I do not intend to discuss the menhaden question, but there is just one point brought up by the last speaker to which I would invite attention. Mr. Hathaway is undoubtedly in error in regard to the spawning of the menhaden. The spawning habits of this fish are now pretty well known, thanks to the efforts of the United States Bureau of Fish-

eries and several of the States on the middle Atlantic coast. There appears to be a double spawning period, quite similar to that of the sea herring on the Atlantic coast of the United States. In spring and early summer the menhaden spawns in abundance on the middle Atlantic coast—northern part of the middle Atlantic and southern part of the New England coast; and in late autumn and early winter the menhaden spawns in great abundance on the southern part of the middle Atlantic coast and the northern part of the south Atlantic coast. Ripe eggs from both of these regions have frequently been examined.

Mr. ALEXANDER COOPER (Delaware). I have but a few words to say. The importance of an international congress to consider the foreign and domestic fisheries of the United States is universally conceded. The time has come when something must be done to preserve the food fish, which are rapidly disappearing from American waters. I speak particularly of the shad and sturgeon fishing along the Atlantic coast, and still more particularly of that great industry as it exists in the Delaware bay and river. The most direct cause of this depletion with us consists in the pollution and contamination of the waters in which these fish live and propagate their species by the owners of oil refineries, factories, and mills permitting their poisonous and refuse matter to flow into the water, thereby practically destroying the spawning grounds or so affecting them as to drive the fish to other localities. There are other causes for this depletion of these fish, which seem to be pretty well known. One of them may be stated in connection with Mr. Hathaway's paper. I have had the pleasure of meeting Mr. Hathaway before. About two years ago I was appointed one of a commission of three from the state of Delaware, to meet with a like commission from the state of New Jersey, to consider a compact which had been entered into between these two states and which has since been ratified by Congress, and to draft uniform fishing laws for the two states, regulating their respective fishing rights in the Delaware bay and river. A serious question presented itself to us in regard to the menhaden fisheries—whether the men engaged in these fisheries caught food fish, and particularly shad. Mr. Hathaway appeared before us and urged that they did not catch any food fish worthy of mention. The shad and shore fishermen contended on the other side that they did—that the shad passed out into the ocean in large schools, particularly in the month of September, swimming on the surface of the water like the menhaden, and were caught like the menhaden, and used as such.

I do not present this matter in a controversial way, but suggestive only, so that the matter can be investigated and, if true, remedied in some way. It has long been an important question to the shad fishermen of the Delaware River.

Mr. GEORGE P. SQUIRES. I heard Mr. Hathaway, who is my neighbor; I have also heard this kind gentleman. I am no lawyer. I am simply a fisherman of fifty years' hard labor. I have this to say to this gentleman and to everyone of this congress. I do it upon the authority of my governor, and do it with pleasure. I do it with the authority of our Association of Menhaden Fishermen of the Chesapeake Bay.

Just as this kind gentleman has stated, the great object is to save the food fish. I, as the president of our association, am authorized to say to gentlemen who are here, foreign or of our own country, that we will welcome them to come among us. We will place one of our steamers at their disposal—any man or men; we will treat you as Old Virginia can treat you. Come, and see for yourselves. Take our crews and work them by yourselves. Come, gentlemen, and see how much the menhaden fishery is a benefit to the future of the fish of our country. Come on!

EFFECTS OF THE MENHADEN AND MACKEREL FISHERIES UPON THE FISH SUPPLY

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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EFFECTS OF THE MENHADEN AND MACKEREL FISHERIES UPON THE FISH SUPPLY.

By W. C. KENDALL,
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SCHOOLING OF FISHES.

There are various degrees of gregariousness among fishes. Probably there are but few fishes that do not swim in schools at some stage of their existence, and there are few, if any, that are always in schools. The very young of most species, as a rule, occur in schools of greater or less extent. The broods of fishes from ova laid in more or less stationary collections or floating agglutinated masses naturally occur in family groups of brothers and sisters. Floating eggs, while sometimes scattered, are perhaps oftener assembled through the effects of winds, minor currents, etc. The young from such eggs to some extent constitute brotherly and sisterly aggregations, though probably they are more frequently mixed broods. Some species commonly regarded as nongregarious are occasionally observed in schools in their young or adult stages.

The schooling habit is so common among fishes that it must in some way be an advantage to them, although it not infrequently is an obvious and decided disadvantage. The most pronounced types of gregarious fishes are comprised in the scombroid and clupeoid groups, but among the species of these groups there is considerable diversity in respect to the habit. The most representative and perhaps the most perfect examples of the schooling fishes of these two great groups are, respectively, the common mackerel and menhaden.

The eggs of the mackerel float. They are supposedly deposited at the bottom, whence they rise to the surface and are subject to the influences of winds, waves, and currents, which factors determine whether they shall be scattered or aggregated.

Practically nothing is known of the place of spawning of the menhaden or the character of its eggs—whether agglutinated, attached to objects, or free, or whether they sink or float. But the fact remains that as soon as the young of either the mackerel or the menhaden are observed they are in schools. The very young of either species have not been observed except in the case of arti-

ficially hatched mackerel. When naturally hatched mackerel are first observed they are at least 3 or 4 inches long, and menhaden have never been seen under 1 inch in length.

Eggs that are stationary or agglutinated, if they are from a single parent and all subject to the same conditions, will hatch at approximately the same time and produce fish of comparatively uniform size. Aggregations of floating eggs are likely to be derived from several parents, laid at somewhat different times, and consequently will produce young of somewhat more diverse sizes. In both instances the rate of growth of individuals varies, causing a difference in size, but on the whole each school of young fish is composed of individuals of fairly uniform sizes. This uniformity appears to be to a great extent permanently maintained; yet it not infrequently happens that schools of two or more sizes become mixed, especially when a school is first broken up by any means and the scattered fish subsequently join other schools.

Whether the schooling habit of the early stage is retained and is the basis of the schools of larger sizes up to adults is impossible to say. That such is the case is indicated by the comparative uniformity in size of individuals of schools of larger fish. Sometimes, however, a school is so large that it could hardly be the original brood or aggregation only, but several, or perhaps many, broods. But such a "raft" is composed of individuals of comparatively uniform sizes, or of sizes suggesting that the fish are of about the same age.

The occurrence of such extensive "rafts" or "bodies" of uniformly sized fish in the spring of the year suggests that possibly the younger fish have a somewhat different habitat from the older ones at that season of the year when they are beyond observation—that is, after they have "left the coast" and prior to their "return." But, as mentioned in the case of young fish, accidentally mixed schools of older fish of the same species, as well as schools containing unrelated species, are not uncommon. Mixed schools of large and smaller fish, or schools containing adventitious species, are likely to occur when the schools have been broken up and driven about by predaceous animals or by purse-seiners. Such broken-up schools or straggling individuals, or even small schools, are prone to fall into the procession when a larger body of fish happens along, even though it is of a widely different species, if it is not inimical. Another possible cause of mingling is when the fish are feeding upon the same kind of food and the food happens for any reason to be bunched.

INADEQUACY OF AVAILABLE INFORMATION.

Since the History of the American Menhaden, in 1877, and a brief summary of that work in 1884, also by G. Brown Goode, there has been little published regarding the habits of this fish. This history is remarkably comprehensive, there being hardly a point regarding the menhaden that is not treated more or less exhaustively. The work was, however, an enlargement of manu-

script notes furnished by Professor Baird, based upon opinions and information elicited by means of circulars from fishermen, manufacturers, customs officers, light keepers, etc., supplemented to some extent by observations by United States fisheries agents. Doctor Goode states that it was found necessary to make allowances for many inaccuracies of statement on the part of his correspondents, and that some of them, having been unable to obtain exact information, had ventured to guess at what they did not really know from experience. It might possibly have been added that some of that which they "really did know from experience" may have been inaccurate from misinterpretation of phenomena or errors of observation. Doctor Goode admits also that there remains much to be learned, but presents his views regarding the most plausible theories, which must, until more thorough and systematic investigations are made, take the place of actual knowledge. These theories have taken the place of actual knowledge, so far as publication is concerned, to the present day, for since Goode's History there is no adequate account of the menhaden accessible to the student or the public.

During the early nineties the United States Bureau of Fisheries made the menhaden and mackerel subjects of special investigation, and a vast amount of data was accumulated, though never utilized, at least in publication. The present writer was engaged in both investigations during those years and has since from time to time had opportunities, of which he has availed himself, to observe both species under various conditions and in various places. It is upon the personal observations thus made, together with some of the unpublished notes in the files of the Bureau of Fisheries, that this essay is based. Owing to present limits of space, however, the writer is compelled to leave his statements mainly unsupported by any transcription of the copious notes mentioned, and also must assume that the audience is familiar with the published literature upon the species herein treated.

HABITAT AND MOVEMENTS OF MENHADEN AND MACKEREL.

That the habits of some fishes of different ages differ to some extent in regard to their food, and consequently their habitat, is well known. It is a matter of common observation to those who have given attention to the habits of the menhaden that the different sizes, as a rule, are found in different places and under different conditions. The smaller the fish, the shallower the water and the farther up creeks and streams it occurs, even in fresh water. This may be for either or both of two reasons: (1) Owing to different character of food of the different sizes, or (2) for protection against enemies. Perhaps the latter is the more probable.

Young mackerel 4 to 5 inches long occur sometimes abundantly well up harbors, even about the docks, where larger mackerel never appear. They have been plentiful in Gloucester and Portland harbors, in the former place sometimes

close to shore in shallow water. As suggested before, in the case of menhaden, they may enter these places for food or for protection, but as they subsist to a great extent upon minute crustaceans which abound outside they could hardly be there solely for the sake of food.

During the period when they are beyond observation it is, of course, not known to what extent menhaden and mackerel feed. But the inference is that mackerel, at least, and probably menhaden, do not feed during this time, as the fish appearing in the spring, which apparently could be only those of the previous season's production, are about the same size as when they left, and early adult mackerel are always lean. A similar condition seems to obtain to some extent among the menhaden, for often the early menhaden are very poor, according to the reports of the fishermen. It can hardly be imagined that the fish would refrain from eating for a long period if food were plentiful unless they to some extent hibernate. If they do not hibernate—become more or less dormant and inactive—it is hard to explain why they should resort to a foodless region when food abounds in other places.

In respect to the menhaden, not so much is known regarding its food as is known of the mackerel, but it has been shown to feed to some extent upon minute crustaceans, as do mackerel, and such food abounds in the winter months in the localities that both menhaden and mackerel have apparently left. The natural inference is then that temperature is the controlling factor. Both menhaden and mackerel endure a rather wide range of temperature and both linger late in the fall in northern littoral waters. Rather curiously, young menhaden seem to remain longer than adult fish and will stand reduction of temperature to a low degree. An experiment made by Mr. Vinal Edwards at Woods Hole, which will be described, supports the statement. The ultimate death of the fish may have been due to the sudden changes of conditions to which they were subjected rather than to the low degree of temperature alone.

On October 16 Mr. Edwards placed in the inner pool of the United States fisheries station about 1 barrel of young menhaden from 2 to 6 inches long. In three or four days they formed together in one school and continued so until December 21, when the temperature fell to 35° F. The school then broke up and scattered about in the pool, some swimming near the surface, others near the bottom. When the sun was shining all would seek the sunny portions of the pool, avoiding the shade. On December 24 the temperature in the pool was 31.5° F. and most of the menhaden swam near the surface but seemed otherwise undisturbed. On December 26 the temperature dropped to 30° and the fish were less active, some swimming on their sides. On the night of December 26–27 it became much colder and snowed, and in the morning all of the fish were dead.

Thus it would seem that the disappearance of young and old in the late fall is to avoid extreme and sudden changes of temperature. They disappear,

but where they go has not been determined. Like all species whose winter quarters are unknown, the menhaden has been consigned by theory to the mysterious depths or contiguities of the Gulf Stream, a region ichthyologically lying beyond the "Pillars of Hercules." Warned by falling temperature, the fish is said to seek a stratum of congenial thermal conditions. All the known facts regarding this species indicate that it makes no extensive coastwise migrations, and since the requisite equable temperature, it is thought, can not be found anywhere else, the fish must find it in or near the Gulf Stream, notwithstanding the fact that so little is actually known about the winter conditions there. But why the fish should seek that locality for so brief a period has not been shown. Mackerel remain in northern waters until November and December and menhaden have been taken in quantities in southern Massachusetts in January, where they reappear in April.

Waters corresponding in temperature with those to which the fish have been accustomed in the summer or early fall could hardly be conducive to inactivity. Activity necessitates food. If the fish are sojourning in the midst of food and in an active condition, they would necessarily eat. Eating, they would continue fat. But mackerel and menhaden when first seen in the spring are as a rule very thin, indicating abstinence from food. If the fish live among an abundance of food, abstinence must be due to disinclination to eat. Such a condition could be ascribed to some degree of hibernation, but that would be inconsistent with warm waters. If, then, the fish is in such winter abode, it must be assumed that there is little or no food there. This, too, is contrary to the usual conditions. Food such as mackerel subsist on extensively, and menhaden to some degree in early spring, is particularly abundant in the spring, at least, in the Gulf Stream and its neighborhood. Moreover, during the alleged fall migrations the fishes are not observed moving offshore. Such movements as are observed are coastwise. After all, the fish are somewhere, but where is yet to be learned. Theory does not satisfy. As spring approaches immense bodies of fish often appear swimming at or near the surface. This appearance of the fish has been ascribed to rising temperature and the breeding instinct. Surely the depths of the Gulf Stream or the equable stratum have not become uncomfortably warm and forced them into the "cold wall" or arctic current? It is conceivable, however, if the fish were at or near the surface of the stream the warming water spread by southerly winds would cause the fish to advance with it. But these conditions are not invariable, and even if they were it would require some other impulse to force them into the much colder northern coastal waters. "Breeding instinct" fails to explain why immature fish are impelled to move in the same way as the adult breeders.

Let it be assumed that the fish—mackerel, menhaden, or other species—have not gone in the winter "migrations" quite beyond the mysterious "pillars;" that they are lurking somewhere along the coast, outside or within the bays, or

both, according to the size of the fish; at a greater or less depth, and, if not dormant or hibernating, that they are more or less inactive and disinclined to rise to the surface, where the temperature and other conditions are so variable and subject to sudden changes; that is to say, they are residing quietly at a depth of comparatively constant and uniform temperature, but of such degree that the fish are disinclined to activity, therefore requiring no food, but subsisting, as it were, upon the accumulated fat of the previous festal period. The regions, too, where, under this hypothesis, the fish reside are different for those of different sizes; in this instance, however, not on account of different feeding habits, but owing, perhaps, to the instinct of self-protection.

It is a well-known fact, as has been previously stated, that young or small-sized menhaden, up to 6 or 8 inches long, linger in the bays long after the larger ones have disappeared. It would therefore seem that the smaller fish are either less susceptible to the changes due to approaching winter, or that some other force predominates over their inclination to leave.

Granting, then, that the foregoing assumptions are true, when spring brings milder weather and less rigorous and sudden changes, the fish appear at the surface and their movements are again to some extent observable.

Regarding adult mackerel, it is known that these movements or so-called "migrations" precede the spawning process, but in immature fish—"blinks," "spikes," "tinkers," etc., which have like movements—this can not be so. In menhaden as a whole it is not evident that the spring "migrations" are for spawning purposes. In the adult of both species the growing ova and milt doubtless warn the fish of the approaching "critical period," but this can not be the case with the immature fish. What, then, is the impelling force that causes the fish to come to the surface and move about in definite or indefinite directions? If the previously suggested hypothesis is still followed, it may be reasonably assumed that the fish, having consumed their accumulated fat, are impelled by their desire for food. If such is the case their movements will be in search of food and in the line of least resistance. Their subsequent movements also, except as controlled by the breeding instinct, whether at the surface or below, will be for food, although they may be directly and indirectly affected by the same meteorological conditions, such as light, temperature, etc. When feeding the schools do not seem to move about very fast in any direction; therefore when in rapid motion they are probably in search of "pastures new." In support of this is the well-known fact that fish are seen going swiftly in directions exactly opposite to those that should be followed according to the "migratory" or breeding instinct. Such movements are usually, and sometimes correctly, ascribed to enemies heading them off and driving them in that direction. But if this were true in every case there should be, and surely would be, some further evidence of the enemies; for whenever the fish have been observed to be pursued by predaceous animals these animals are quite conspicuously manifest.

The movements of both mackerel and menhaden when feeding, as mentioned before, are not rapid from place to place for any great distance, but up and down, here and there, and around and around in that movement termed "cart-wheeling." While the latter movement is considered by many "just play," the manner of occurrence of minute organisms in aggregations of greater or less extent suggests that the fish are circling about in a school of these organisms, "scooping them in."

SPAWNING MIGRATIONS OF THE MACKEREL.

Regarding the migrations of fishes to their spawning places, every known fact in relation to menhaden points to no extensive migration for the majority of the fish. Mackerel apparently travel greater distances, but there is no evidence in support of the former belief that they traverse the whole length of the coast from Hatteras to Labrador and the Gulf of St. Lawrence. It is hardly possible that one man would have sufficient endurance to observe day and night a body of fish for so long a period, and a change of watch would vitiate the evidence. While it is perhaps possible that a body of mackerel would remain at the surface continuously day and night, it is more than merely probable that it would occasionally sink below the surface. If it did, the observer could not be sure that the fish appearing subsequently were the same school.

Some years ago mackerel sighted by the seining fleet off Liverpool, Nova Scotia, were "followed" along the coast and around the eastern extremity of Cape Breton. The fish were up and down, sometimes a day or a night elapsing with no fish seen. It was noticed that while the schools of mackerel along the western portion of the Nova Scotia coast had alewives and shad mixed with them, those caught after rounding the eastern end of Cape Breton had none of these adventitious fishes, but many schools were mixed with large herring, called by the fishermen "Newfoundland bloaters." Here, too, the mackerel were somewhat larger than those on the south shore.

Of course in the nature of things there is nothing to prevent the mackerel constituting the "body" from varying in size in different schools, each school perhaps having different fish mixed with it. But it is hardly probable that had the alewives gone around Cape Breton, or the herring been at the south or west of that point, some would not have been caught there. This gives rise to the suspicion that extensive migration is more apparent than real.

The condition of the reproductive organs of these fish, too, indicated that they were near the spawning time. According to the observer, each batch examined was thought to be within a week or so of it, which suggests that the fish may have been spawning along the coast. That those caught were not ripe offers no contra-argument. For it is possible that as the fish ripened they sank to some depth below the surface, where they spawned, and occasional few spent fish indicated that all did not reappear immediately afterwards. It is

well known that some fishes linger on their spawning grounds long after they have spawned, and it is not impossible that mackerel remain near the place where the spawn is deposited for some time afterwards. The same may be said of menhaden. In support of this is the fact that sooner or later all adult menhaden disappear from the Virginia shores and, temporarily at least, from the Carolina coast. There are not wanting fishermen, however, who aver that they catch menhaden along the Carolina shores at any time in suitable weather throughout the winter.

SPAWNING OF MENHADEN.

The time, place, manner, and duration of the spawning act of the menhaden are not known, and such meager data as are available on that subject are confusing. Direct observations by persons qualified to solve the problem have not been made, and the testimony of those who handle the greatest number of the fish is contradictory; individuals not infrequently change their views—sometimes even while being interviewed. Conjecture, however, is not evidence, and until thorough observations are made throughout the year the question can not be positively settled. But careful study of such data as are at hand suggests that there is no one definite spawning season such as appears to be the case with mackerel, but that the conditions are analogous to those of the common herring, which spawns in some localities in spring or early summer and in others in late fall or early winter, and perhaps more or less all summer. Some menhaden taken in Buzzards Bay throughout May and June up to July 15 are well advanced, and a few ripe fish have been observed; but of the many examined few are found that are more than "well advanced," and it is unsatisfactory to try to estimate the length of time necessary to ripen the "well-advanced" fish. Out of 500 large menhaden taken at Sakonnet, R. I., on July 5, 1892, 410 were females in various stages of development from very small to "nearly ripe." Of the 90 males, the majority contained milt "well advanced" and some were "ripe." From November 17 to 20, during the same season, at North Truro, Cape Cod, large menhaden were found with ova and milt in various degrees of development, some males being "well advanced" and a few females "nearly mature."

From the last part of October to the first of December, 1894, a large body of menhaden was observed to extend from Delaware Bay to Cape Lookout, "outside." These fish differed in appearance from the few taken within the bays at this time, being longer and their reproductive organs apparently very near maturity. Very many taken off Chesapeake Bay were examined, and the organs of those over 10.5 inches long always seemed to be in the same condition, which the observer could account for in no other way than that the fish were passing south toward warmer water to spawn. Subsequent observations off the

coast of North Carolina in the vicinity of Beaufort, however, revealed hardly any appreciable change in the conditions of the reproductive organs.

It is the consensus of opinion among the fishermen of the Chesapeake that the "bay menhaden" spawn in February and March, and they present evidence to that effect. But they believe that the outside fish in late fall spawn at sea near the Gulf Stream or off the coast farther south.

In May, 1908, there was received at the United States National Museum a portion of a menhaden the length of which indicated that the whole fish was about 13 inches long. It contained undoubtedly nearly ripe roe. It was caught in the Chesapeake on the 8th of April and was brought in to Solomons, Calvert County, Md. This suggests, at least, that the opinions and statements of the fishermen regarding the spring spawning of menhaden in the Chesapeake may be correct.

The above-mentioned occurrence of large bodies of menhaden outside, apparently near spawning condition, suggests also a fall or early winter spawning in that region, as do the data regarding the fish at North Truro. But the lack of knowledge regarding the length of time that would be required for the ova to mature prevents positive conclusions, for, instead of a few days or a week or two, a month or two or more might be necessary. The latter condition would bring the fish to maturity in February or March. In favor of the fall spawning, however, is the fact that a few undoubtedly recently spent fish were secured.

The evidence derived from young fish is unsatisfactory, since very little is known of their rate of growth. Young menhaden are seldom seen in the Woods Hole (Mass.) region before July, when they range from 1½ to 3 inches in length, more often from 1½ to 2 inches. In November in the same locality they range from 2 to 5 inches in length, the majority being about 3 inches long, and all through the season there is another lot of immature fish, which, perhaps, average 8 inches in length.

In Chesapeake Bay young menhaden are said to appear in May, when they run from 1½ to 2 inches in length. In March, 1894, young menhaden from 4 and 5 to 6 and 8 inches long were collected, and again in July from 1½ to 5 inches. This indicates that there are two stocks of young fish—the earlier, perhaps, from the breed of the previous fall, and the later and smaller from that of the spring of the same year.

It has been suggested, because adult menhaden are seen far up bays and streams and the young are found still farther up, that the fish spawn in these localities; but there is nothing to indicate this. Fish, especially the young, run into shallow waters and often long distances up streams—even to the headwaters of small streams and creeks—probably, as has been previously stated, to escape enemies.

The most that can be said regarding the spawning places of menhaden is that nothing is positively known.

RELATION OF MENHADEN TO FISHES THAT FEED UPON THEM.

Goode says:

Among the enemies of menhaden may be counted every predaceous animal which swims in the same waters. Whales and dolphins follow the schools and consume them by the hogshead. Sharks of all kinds prey upon them largely; one hundred have been taken from the stomach of one shark. All large carnivorous fishes feed upon them. The tunny is the most destructive. * * * The pollock, the whiting, the striped bass, the cod, the squeteague, and the garfish are savage foes. The swordfish and the bayonet fish destroy many, rushing through the schools and striking right and left with their powerful swords. The bluefish and bonito are, however, the most destructive enemies, not even excepting man; these corsairs of the sea, not content with what they eat, which is of itself an enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments. Traces of their carnage remain for weeks in the great "slicks" of oil so commonly seen on smooth water in summer. * * * I estimate the total number destroyed annually on our coast at a million million of millions; in comparison with which the quantities destroyed by men yearly sink into insignificance.

Such estimates, Goode states, are only approximate. It may be a question as to whether they are even approximate. If he deduces his estimates from a sufficient number of well-established facts, they may be considered approximate; but the evidence is that he reaches his conclusion by induction from a limited number of facts. One shark is known to have eaten 100 menhaden. One shark might contain 1,000 menhaden as a day's feast, but that would not be sufficient evidence upon which to base a conclusion that all sharks eat 1,000 menhaden each day in the year. One tunny may have been observed to almost annihilate a school of menhaden, but it does not follow that all the tunnies in the region consume a school of menhaden each every day. A school of bluefish is occasionally seen to wreak havoc upon hundreds of menhaden, but it does not sufficiently indicate that they do it every day. One squeteague having been found to devour nearly 50 menhaden does not clearly prove that the exclusive menu of the squeteague is nearly 50 menhaden a day. An average of 100 menhaden a day to a shark or its equivalent for three hundred days would require 333,333,333,333,333 sharks, or their equivalent in eating capacity, to devour a million million of millions menhaden in that length of time.

It is not a justifiable assumption that all of the predaceous animals previously enumerated feed exclusively and daily upon menhaden, even during the time that they are concurrently on the coast. Among fishes concerning whose habits we are better informed than those under discussion, it is known that they change their diet from time to time, and there are periods of days when they do not feed at all. One is almost as fully justified in assuming that a fish which is found to have eaten nothing during the day does not feed at all as that one found to contain a few menhaden feeds continuously and exclusively upon menhaden. Yet undoubtedly enormous quantities of menhaden are destroyed annually by fishes and other predaceous animals. Professor Goode further remarks that in estimating the importance of the menhaden to the United States it should be borne in

mind that its absence from our waters would probably reduce all our other sea fisheries to at least one-fourth their present extent. If his premises are sound, the estimate is probably approximately correct, otherwise it is subject to criticism. In the Gulf of St. Lawrence, where, for a portion of the year at least, the principal food of the cod is capelin and herring, the absence of these foods is concomitant with the absence of cod.

In the second report of the Commissioner of Fisheries of the United States, Baird ascribes the decadence of the inshore cod fishery of New England to the enormous diminution in the number of alewives; "at least," he says, "the coincidence is remarkable." If the same relation is known to exist between the cod and the alewives on the New England coast as between the cod and herring or capelin in the Gulf of St. Lawrence, then such a conclusion is well founded. But as it is not shown to be a fact, it can be considered only a conjecture. Surmises based on coincidences will not solve problems. Therefore, in order to determine even with any degree of approximation the effects of the reduction in numbers of any species in our waters upon other species to any extent feeding upon them, the habits of not only these forms but others as well must be very thoroughly known in all their intricate interrelations.

The list of fishes enumerated by Goode as destructive enemies of menhaden does not comprise all the species that at times eat menhaden, and it includes some that are not known to feed upon them at all. The assumption that they do is made partly from the fact that they are built on the model of predaceous fishes, and partly because they are sometimes caught on menhaden bait. The first part is to some extent justified, since it is safe to assume that a species which to any extent eats other fishes will eat menhaden if it can get them; but it is not safe to infer that it consumes enormous quantities, as its habits may be such that it is not brought in contact with such numbers, or food which it prefers may be at the same time present. That a fish is caught on certain kinds of bait or that the bait is the most successful to use does not signify that the principal food of the fish is the species used as bait. Not infrequently the best bait for some fishes is something that does not coinhabit those waters.

To what extent any species subsists upon menhaden and the number of species that feeds to some extent upon them is not known. Therefore no reliable deductions can be made regarding the effect upon such fishes were they deprived of the supply of menhaden. However, every menhaden caught reduces the number of those fish by one; every thousand or million reduces the number by a thousand or a million. Therefore the menhaden fisheries must, theoretically at least, have their effect upon the species that feed upon the menhaden by depriving them of so much food. They also have effect upon the menhaden sought by rendering those that escape capture more liable to be eaten by predaceous enemies.

Whether the effects of fishing are of appreciable injury to the fish depends upon the time, place, and amount of fishing, as well as upon the habits of the fish and the number caught. If the fish have a limited spawning ground to which they resort every year—for instance, a small bay, estuary, or mouth of a stream—constant fishing with purse seines and obstructive pounds and traps must necessarily seriously affect the number of fish reaching the spawning ground, consequently the number produced that season. And if such fishing is carried on at or near every spawning place of the species, as well as at a distance from it, the injurious effects would obviously be still greater, and in time would result in a diminished number of the species. If the species is greatly reduced in numbers, then the food supply of the fishes depending upon this particular species for subsistence is correspondingly reduced. The consequence of this would be that this species would be reduced by starvation or would be forced to depend upon other species for food. The latter is the most natural effect, and this in turn would deprive still other species of their food or reduce their numbers either as adults or young, or both. Other species being deprived of their food would repeat the process, and thus it would go on until nothing remained.

While such a condition is theoretically conceivable, it is not so in fact, except to the extent that if for any reason the food of a species is withdrawn the species disappears, doubtless in search of food elsewhere, and when its principal food is abundant the fish feeding upon it would naturally be plentiful. Exceptions that might be cited may be only apparent, for, as has been previously suggested, probably no fish feeds exclusively upon any one thing or depends upon any one species. The shark, tunny, or bluefish would hardly be likely to distinguish schools of menhaden from schools of other silvery fishes like the alewives, which sometimes equally abound with the menhaden along the coast. Thus the absence of bluefish from any section when menhaden are present or the presence of bluefish when menhaden are absent in each instance is due to the same thing—the presence of satisfactory food in one place or the other. There is no doubt that the bluefish disastrously pursues menhaden, but it is known to pursue other species with equal disaster.

The effects of the complete extermination of menhaden from the seas may be inferred from the effects of local disappearances for a term of years and where there is no evidence that the fishes that fed upon them there suffered in consequence of their departure. It may with propriety be stated here that such "unaccountable" disappearances took place long before modern fish traps and purse seines were known. Subsequent like disappearances and reappearances, again disappearances without reappearances, can not, then, logically be laid to the purse seines and steamers. But there can be no doubt in the minds of those who have observed the operations of menhaden and mackerel purse seines that there is at least a temporary more or less modifying

effect upon the movements of the schools of fish. It may still, however, be an open question whether the mackerel have not always been fully as intelligent as they now seem to be when they evade the nets so successfully that the fishermen call them "educated fish."

CONCLUSION.

In this paper there has been no attempt to explain the mysterious phenomena exhibited by the fishes discussed, but merely to suggest lines of investigation that might be worth making. There have been frequent more or less critical references to the contributions of Baird and Goode, but with no wish to attempt to controvert any of their sound arguments. The theories advanced by them are as logical and sound as the evidence upon which they were based would permit, since the conclusions were reached by assembling and sifting the testimony of unscientific observers. Such evidence is difficult to collate satisfactorily, owing to the more than frequently contradictory character of even that obtained from intelligent, observant, and equally honest persons. The views of the purse seiner may be quite contrary to those of the gill netter, trap, or pound fisherman, yet each probably is honestly convinced of the correctness of his views.

It is needless to say that in this paper few, if any, new facts have been added to the knowledge of the fishes to which it refers. But its object will be attained if, by indicating possible errors in the theories previously held, it causes a realization of the prevalent profound ignorance regarding the greater part of the life of many of our common and commercially important fishes and almost total lack of knowledge of the habits and life history of the menhaden, and thus proves instrumental in instigating the much needed thorough, systematic investigations of those subjects.

AN IMPROVED AND PRACTICAL METHOD OF PACKING FISH FOR TRANSPORTATION

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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By A. SÖLLING,
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It was about forty years ago that ice was with good result first used on board English fishing ships for packing fish. Before that time fishing ships made only short voyages, to insure the fish reaching market in a good condition. But it was necessary to bring in the best and firmest fish only, those that could be kept fresh the longest time, such as soles, turbot, brill, and halibut, which fish retain the name of "prime fish." Other kinds of fish, such as plaice, cod, and haddock, could not be brought in, as they would not keep, and so had to be thrown overboard as useless.

In the eighties, when steam trawlers were introduced for fishing purposes, the fishermen went away for ten to fourteen days, sometimes three weeks, for their catch, and it was then necessary to make provision on board for a large quantity of ice, so that the catch might reach port in good condition. In spite of this precaution, however, a large quantity of fish caught at the commencement of the voyage was, and is still, landed in a very poor and stale condition, especially during the heat of the summer. People seem to enjoy iced fish, even though it has lost its flavor, believing that there is no possibility of procuring it otherwise. But when they have once tasted good fresh fish, cooked immediately after being caught and killed, they lose their taste for iced fish at once.

It was after seeing the poor treatment to which fish is exposed in England, from the moment it is caught—carried in ice in the trawler's hold, discharged and repacked, and finally laid out on the fishmonger's marble slab, occasionally being sprinkled with lukewarm water to make it shine—that I was led to experiment for a means of packing fish for transportation and keeping it in a better and sounder condition.

Many different experiments have been made in an effort to find the best and most practical means of keeping fish fresh and sound for a lengthened period, but all these methods, whether with or without the use of chemicals, have been found wanting in efficiency, the fish losing its fine appearance, and more especially its flavor.

Freezing is a good and sound method of preserving, but it is difficult to keep the fish frozen in hot weather on long distances, as for instance on railway journeys. Moreover, on being thawed the fish lose their flavor, and they soon decompose on exposure to the deleterious influence of the air. Packing in ice is a method in very general use for transportation, but as the fish is constantly in close contact with the ice and ice water this method also has disadvantages. The idea in using ice is, of course, to keep the temperature low, thereby preventing decomposition as long as possible. But the exposure to ice and ice water destroys the flavor of the fish; they become stale, and when exposed to the air they quickly decompose, especially during mild weather.

The chief thing to be kept in view in preserving food is to keep it as free as possible from harmful bacteria and from the surrounding air charged therewith. It is, furthermore, necessary to prevent the ice water, which is also more or less full of bacteria, from coming into direct contact with the fish, but at the same time using the low temperature produced by the ice to prevent the further development of the bacteria invariably contained in the fish.

In using my method of wrapping fish in improved fish-wrapping paper and afterwards laying it in crushed ice, the latter in pieces about the size of a walnut, the air is excluded and the ice water prevented from coming in direct contact with the fish. The low temperature of the ice is acting directly on the fish through the paper, and by these means the fish is kept sweet and fresh for a longer period than is otherwise possible, the bacteria of decomposition being thus prevented from developing.

The chief point to be observed in this method of packing fish is that the fish be gutted and bled and the gills cut out as soon as possible after the fish are caught. The sound, found in some species, must be cut lengthwise to insure the removal of all blood particles underneath. Further, the fish should be cut open so far behind the vent that all accumulations of blood may be easily removed. They are then washed and scrubbed inside and out with a stiff brush in clean salt water, or in a solution of fresh water with 4 to 5 per cent of salt, until all blood specks have been removed, then they are laid aside for a short while to allow the blood and water to drain off, and very special care must here be taken that no water be left remaining on the inside. Each fish is then carefully wrapped in the wrapping paper, which is cut square, each dimension being at least one and a half times the length of the fish.

To wrap, place the fish across the nearest corner of the sheet, roll it over very firmly, turn in the two side corners, and roll the package over again until the fourth corner is reached, then tie with a piece of twine.

Objection might be raised that too much trouble is involved in treating fish in the above manner, and that it takes too much time. But the time,

trouble, and small expense incurred are very soon repaid by the higher prices which are obtainable for the fish, owing to their far better appearance, and to the very important fact that they will keep fresh after fish that have been treated in the old way have spoiled. The fishmonger, too, will soon find his profit in having for sale fish which not being sold to-day will turn out just as fresh eight or fourteen days hence, even in the hottest weather. It may be remarked that all kinds of fish may not profitably be treated according to this method, but prime fish, such as soles, turbot, brill, halibut, and haddock, perhaps cod and plaice, will fetch a much higher market price if so treated.

The more expensive fresh-water fish, such as salmon, carp, and trout, are always shipped in ice without being gutted, but even they would have a far better appearance if wrapped in this paper instead of being exposed to the influence of air and ice water. I would here, however, draw attention to the fact that the fundamental feature of my method of wrapping fish is that the fish be gutted, that the entrails and the gills be removed, and the fish thoroughly washed.

The first important experiment with the method here presented was carried out in October, 1905. The necessary fish were caught by special permission of the Danish Government in the steamer *Thor*, which otherwise was engaged in international sea investigations. For the purpose of comparison the fish were packed in four different ways:

1. Gutted, wrapped in paper, and laid in ice.
2. Not gutted, wrapped in paper, and laid in ice.
3. Gutted and, without paper, laid in ice.
4. Not gutted and, without paper, laid in ice.

Altogether 147 fish were packed in these different ways. The flat fish included soles, turbot, brill, plaice, lemon soles, and whitches; the round fish were haddock, cod, whiting, hake, and gournard.

On October 6 and 7 the fish were packed, and on October 17 the method was explained and specimens of the different kinds of fish were shown to people interested, including press representatives, fishmongers, and others well acquainted with such matters. The following results were revealed:

1. The fish gutted and wrapped in paper and ice were perfectly white and firm, without any smell whatever, the skin was not discolored, and most of the fish had retained the stiffness of death.

2. The fish not gutted but wrapped in paper and ice were in most cases damaged in the inside.

3 and 4. The fish gutted and not gutted (round) and not wrapped in paper but placed in direct contact with air and ice water were soft and stale and the skin discolored.

On October 21, fifteen days after having been wrapped, some of the fish packed under method no. 1 were taken out and examined. Seven different kinds, after being boiled, were found perfectly fresh and to have retained their flavor in full.

Another test, the following spring, gave results as follows:

On March 26, 1906, 3 halibut weighing about 2 stone each were packed in Grimsby, according to my method, and the same day sent by steamer to Copenhagen in a box containing ice. To afford a comparison, a fourth halibut, treated exactly as the others except that it was not wrapped in paper, was inclosed in the same box.

On April 9, after having been wrapped up for fourteen days the first halibut was taken out, and I was informed (not being present myself) that it was found perfectly fresh and without any discoloring of the skin at all. The halibut which had not been wrapped in the paper and therefore had remained in direct contact with the ice was discolored on the skin and was quite stale.

On April 20, after being wrapped for twenty-five days, the second halibut was taken out in the presence of several well-known gentlemen, when I also was present. It was found fresh, firm, and white in the flesh, and, after being cooked, to have retained its full flavor.

On April 26, after being wrapped for thirty-one days, the third and last halibut was taken out, and found to be firm and white and also without any discoloring of the skin. It was tasted by several people, myself included, and found to have retained its full flavor.

A third practical experiment was carried out by order of the Royal Greenland Trading Company, of Copenhagen. Thirty-nine halibut caught in Davis Strait were treated according to my method on August 12, 1906, and forwarded in boxes filled with ice in the steamer *Hans Egede*, which landed them at Peterhead on September 1. The fish, in the boxes, were sent by rail to Grimsby, where they arrived in splendid condition and were sold on September 3, fetching a comparatively high price.

Upon the basis of the different experiments, I can safely affirm that by wrapping fish in this manner and treating them as described they can be kept fresh for a much longer period than is possible by the old method. Further, in consequence, the fish will prove to be a far better and more healthy food when treated in this manner than when kept in direct contact with air and ice water.

I would mention in conclusion that my method of packing need not be limited to fish. Meat also will keep during the hottest weather when wrapped up perfectly fresh and laid in ice; and for experiment lobsters boiled in Canada have been sent to London. After being boiled and cooked, the lobsters were wrapped in the paper and sent in cases with ice, as a result retaining their full flavor for about fourteen days.

The paper I use is called vegetable parchment, but I prefer to call it simply fish wrapping paper, for by employing this name I am able to retard the use of bad imitations with the consequent poor result and possibly damage to the reputation of my improved method of packing. The paper is at present to be had only in London. It is of two weights, the heavier parchment a dark brownish gray, the lighter weight a yellowish brown. The dark heavy paper, for wrapping large fish such as halibut, will shortly be made in sheets 5 feet square. The yellow paper, for wrapping smaller fish, is to be had in sheets 28 inches square.

A PROCESS FOR PRESERVING THE PEARL-OYSTER FISHERIES AND FOR INCREASING THE VALUE OF THE YIELD OF PEARLS

By John I. Solomon, B. Sc.

Presented before the Fourth International Fishery Congress, held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of one hundred dollars in gold offered by the New York Academy of Sciences for the contribution, not entered in competition for any other award, which should be judged to have the greatest practical value to the fisheries or fish culture

A PROCESS FOR PRESERVING THE PEARL-OYSTER FISHERIES AND FOR INCREASING THE VALUE OF THE YIELD OF PEARLS.

By JOHN I. SOLOMON, B. Sc.

CONDITIONS IN THE PEARL-OYSTER FISHERIES.

The process of obtaining natural pearls is carried on throughout the world to-day in precisely the same manner that it has been done ever since mankind has prized this product of the sea as a gem. The only qualification that can be made to the above statement is that since the invention of modern diving apparatus there has been, in certain parts of the world, a modification in the method of securing the pearl oyster. This so-called improvement, however, has perhaps done more, within a very few years, to deplete former valuable natural beds than had centuries of previous fishings, when the ability of man to strip the beds of all the oysters they contained was prevented by the limitations of naked diving. The divers could then go to but comparatively shallow depths, and could gather the oysters only in a haphazard manner as they groped about for a minute or two at the bottom. Also, because of the inability of naked divers to carry on operations in any but calm and warm weather, the season for fishing was comparatively short. As a result of these conditions the beds in even comparatively shallow waters were never entirely stripped of all their oysters, while those lying at depths greater than the physical ability of the divers to reach were untouched. There were thus always sufficient oysters left for breeding purposes, and in spite of the wastes of the method for securing the pearls—the killing of all the oysters to get the contained pearls from about 10 per cent of them—the beds continued to give a comparatively uniform yield.

Since the adoption of diving apparatus the conditions have entirely changed. With the divers enabled to remain under water for a considerable period and in weather which would prohibit naked diving, and to go to greater depths and work in a thorough and systematic manner, the old natural beds have been completely stripped, and beds heretofore inaccessible have been or are being depleted in the same way. This has already been accomplished in most parts of Australia, the waters off Thursday Island, Costa Rica, the Mergui Archipelago

of Lower Burma, and in practically all the places heretofore fished by white men. The business in the East, excepting the fisheries of Ceylon and the Persian Gulf, where the local fisheries and conditions due to the nature of the oysters and other local influences are peculiar, is now practically in the hands of Japanese and Chinese, who alone are satisfied with the small returns from the now meager beds. The Europeans formerly engaged in the business are seeking other occupations. In Burma most of them have gone into tin mining, and at the present time just a single white man is there engaged in the pearl industry. In Australia and the islands of the East Indies there is a constant exploration now for virgin beds and a seeking for better divers and apparatus to go to greater and greater depths. There one hears a constant wail at the limitations of man and his apparatus to combat the great pressures of depths where the oysters are supposed still to be in abundance, and the more imaginative, speculative, or daring are now talking of submarines to go after the oysters. In this connection I would state that a submarine of special construction has recently been built in France for sponge fishing in the Mediterranean off the coast of Algiers.

As a result of the wastes of past and present methods and the general conditions of the industry as now carried on, both in the pearl fisheries of the seas as outlined above, and in connection with the fresh-water pearl fisheries of the United States and other countries, the statement has been freely made in the past few years by prominent pearl dealers of Europe and America that no large pearls will ever again come to market, except those in the possession of eastern magnates and potentates who may be induced by the extravagant prices offered to part with heirlooms held in their families for generations. In other words, the pearl of size and value is tending to extinction. Although the scientific propagation of oysters and other shellfish has been made a great commercial industry in Europe and America, the idea of conserving the pearl-oyster beds and attacking the problem of securing pearls and shells other than by the ruthless destruction of the natural beds seems never to have entered the minds of those engaged in the industry. I have never received any encouragement from a single one of them with whom I have corresponded or whom I have met; and although the installation which I have myself started has proved the undoubted soundness and utility of the process, and the fact of its establishment has now become more or less known throughout the East, I have yet to learn of the interest of any individual or corporation engaged in the pearling industry. In view of the recent agitation in the United States because of the destruction of the fresh-water mussel pearl fisheries, I hope that in my own country more interest will be disclosed.

PRINCIPLE OF THE PROCESS.

An electrical engineer by profession, my first knowledge of the pearling industry was gained through an acquaintance with a family having social and

business relations with Colombia, Panama, and Costa Rica, who thereby had a knowledge of and who dealt in pearls fished in the waters of those countries. It was because of this acquaintance and the knowledge thus gained of the conditions that I conceived the idea of utilizing the X ray for preventing the losses and wastes of present pearling methods and for increasing the yield of fine pearls. In this connection, I would state that I am not the first to have thought of utilizing the X ray for these purposes. Although I did not know it until later, Prof. Raphael Dubois, of the University of Lyons, had a few years before suggested such a use of the X ray. I had the pleasure, in the month of December, 1907, of paying a visit to Professor Dubois. But from a particular question asked by him I found that his investigations had been slight and not very extensive on living oysters.

The question asked by Professor Dubois was one which I had great difficulty in explaining away to the laymen whom I induced to become financially interested in my enterprise, "Will the X rays kill the oysters?" I had made this test at the very commencement of my experiments, once I had become enabled by skillful exposure to disclose pearls which I had placed inside of large Rockaway oysters in New York. Having previously made arrangements at the New York Aquarium, I placed in tanks there live oysters which I had subjected to continuous exposure of powerful X rays for as long as a period of ten minutes. These oysters lived for months without showing any ill effects whatever. In my process the time of exposure is not one-tenth of this. I made this experiment only in order to satisfy the minds of my subscribers, for, after consultation with specialists having a full knowledge of the physiological and pathological effects of X rays on animal tissues and organisms, I was myself convinced that the slight exposure necessary for the process could have no effect.

My first intention and experiments were with the idea of using the fluoroscope for the detection of the pearls within the living oysters, but having learned that in Ceylon they had taken as many as 41,000,000 oysters at a single fishery (one season) I saw that the conditions were not as in Costa Rica and some other places. I accordingly adopted a radiographic method. A comparatively few oysters may be examined individually and carefully by means of the fluoroscope, but by the other method great numbers may be automatically handled and many inspectors may leisurely examine radiographs made practically automatically; and the radiographic method in practice has done all I expected it to do. In the same time that would be required to examine a single oyster by the fluoroscopic method a single tube and operator can make radiographic images of hundreds of oysters, and, as has been found in surgical work, a radiograph will show up more minute particles and detail than can ever be disclosed by a fluoroscopic examination.

In order to accomplish the object sought, I had to devise a process and apparatus, and I subjoin hereto a description and the claims of the first of several

patents which have been granted to me by the governments of Australia, Ceylon, India, Japan, and other pearl-producing countries, or countries which have pearl-producing colonies and dependencies.

DESCRIPTION OF INVENTION AND CLAIMS AS PATENTED.

The object of this invention is (1) to provide means for taking radiographs or of making fluoroscopic examinations of separate pieces of matter or objects in considerable quantities, so that they may be taken simultaneously for the purpose of making radiographic examination of these objects and pieces of matter, and then (2) readily to identify each radiograph as being that of the particular object or piece of which it is the representation.

The manner of taking radiographs at present is to make exposures of individual objects placed upon photographic plates, or other sensitive radiographic media, either in direct contact or with the plate properly inclosed in paper to keep out light. The exposures having been made, by means of the X rays, Röntgen rays, or any other rays penetrating matter opaque to light, the object is removed from the plate or other sensitive medium and set aside, the sensitive medium being then developed through ordinary photographic process and examined.

This method is cumbersome and expensive, and precludes the radiographic examination of many different materials. Also it can not be utilized in connection with large bodies or numbers of objects for commercial purposes. My particular aim in connection with the present invention is the ascertaining of the presence of pearls of any size or form in pearl oysters (*Margaritifera vulgaris*) without injury to the oysters; but the invention is not limited with respect to the character of the objects under examination, as it may be used for any objects whatever. Ordinary processes and apparatus could not be used for this purpose, for the reason that they would be too cumbersome, slow and expensive, and entirely unsuited.

For the purpose of examining the material quickly and cheaply, I utilize a tray or conveyer of considerable surface, over which the material may be spread or carried, and this tray or conveyer is then laid upon the sensitized radiographic medium. The latter is of a size larger in area than the tray or carrier itself, the excess being sufficient to allow for the distortion due to the rays falling upon the outer area at a considerable angle.

The exposure having been made, the tray is lifted from the sensitized medium, or in the event of the conveyer it is so adjusted as to be carried beyond the sensitized medium. The latter is then developed, and the resultant radiograph, which is the full size of the tray, except for the increase in size due to the distortion, can be compared to the objects or material on the tray itself, these objects or material not having been disturbed, and occupying at this time the same relative position as in the particular radiograph on the sensitized medium.

When pearl oysters are the objects examined, the pearls will clearly appear in the radiograph, as they obstruct the passage of the rays to a greater extent than other portions of the oysters. I also use in connection with the tray or conveyer a means for identifying the particular group of objects which have been radiographed so that the radiograph may be afterwards compared with the objects on the tray and their identity established. With pearl oysters, those that have pearls may thus be identified, and the position and size of the pearls be ascertained, without destroying the oysters.

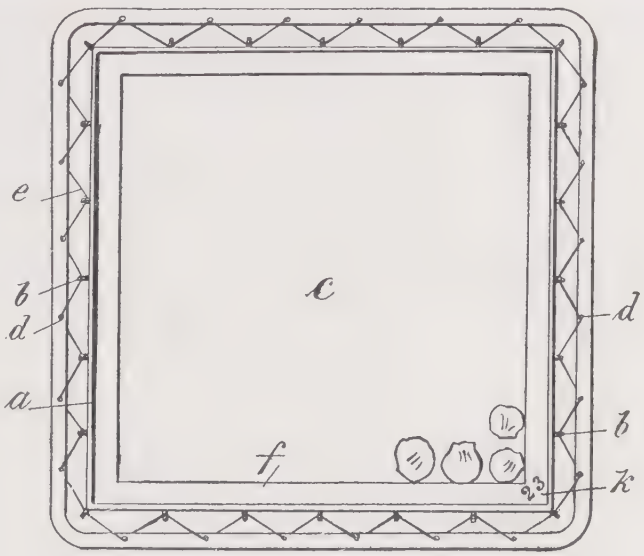

FIG. 1.—Plan of tray to contain pearl oysters for radiographing.

The essentials of the tray bottom or conveyer are two: (1) That the material be composed of a substance which renders little or no resistance to the passage of the X rays, Röntgen rays, or any other rays penetrating matter opaque to light, and allows them to affect the sensitized medium practically as though it had not been interposed; and (2) that the tray bottom be as thin as possible, in order that the matter when held on it be but little further away from the sensitized medium when on the tray than when placed directly on the sensitized medium, so that as good definition as possible may be obtained.

The tray may be of any shape or size desired, and may be constructed of cork, fiber, wood, fabric, aluminum, celluloid, vulcanized rubber, or any other material the qualities of which, as outlined above, are such as to afford the least amount of resistance to the rays. That wet objects may be examined without warping or distortion of the tray, I propose that a tray be made with the bottom of canvas, duck, or other such fabric. Such a receptacle is shown in the attached drawings, of which figure 1 is a plan and figure 2 a longitudinal section. It consists of a rigid frame (*a*) made of strips of metal, wood, or other suitable material, and having hooks or pins (*b*)

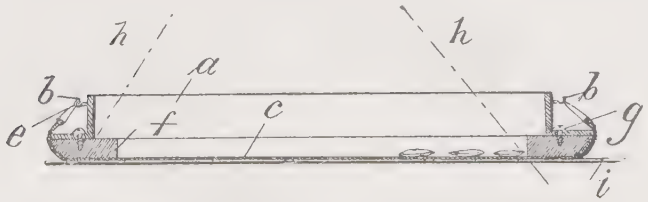

FIG. 2.—Longitudinal section of tray shown in figure 1.

on the outside. The canvas (*c*) can then be placed under this frame, and having suitable eyelets (*d*) in its edge, can be stretched tightly upon the frame by a lacing (*e*) which is passed through the eyelets (*d*) in the canvas (*c*) and the hooks or pins (*b*) on the frame. In order that the radiographs of objects along the sides may be complete and properly made, and be not intercepted by this frame (*a*), another frame (*f*), of wood or other material which will allow the rays to pass through, is placed between the canvas and the first frame (*a*) and secured to the latter by means of screws (*g*). The frame *f* projects sufficiently inside of the frame *a* to hold the materials that are being examined at such a distance that the rays (*h*) pass through the very outside of the material, clear of the frame *a*, and will produce the desired effect upon the sensitized medium (*i*) underneath the tray.

Upon the tray and preferably upon the second frame (*f*), or upon the canvas, is placed a number, letter, or some other device by which to distinguish the trays from each other. This sign (*k*) is here shown as a number (23), cut out of metal,

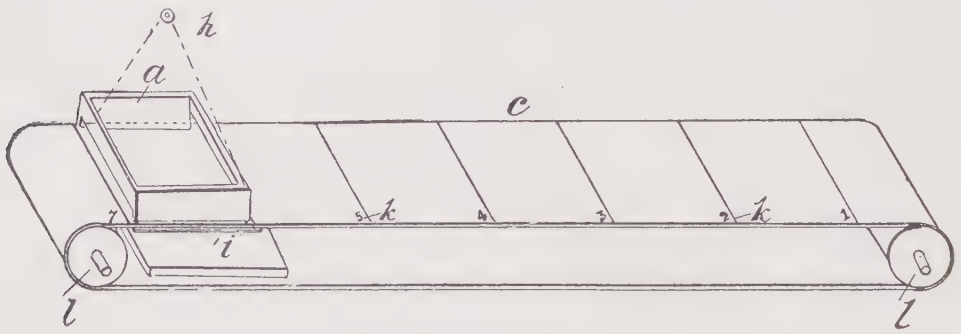

FIG. 3.—Conveyer to substitute for tray of figures 1 and 2.

which is impervious to the ray, and properly secured to the frame *f* or the canvas.

The invention may be modified, as, for instance, by substitution of a conveyer in place of the tray. One form of conveyer is shown in figure 3. Here the canvas (*c*) is an endless strip passing over rollers (*l l*). The frame (*a*) is shown as raised above the canvas a sufficient height to allow the objects placed upon the canvas to be moved under it. The canvas is in divisions equal in size to the frame, and each division is provided with a distinguishing mark (*k*), as already described. In operation of this modification, the objects are placed within the frame and upon one division of the conveyer. The sensitized medium (*i*) is placed under it as shown, and the radiograph is then taken. The conveyer is then moved by turning one or both of the rollers, so that the objects will have passed to one side and an uncovered portion of the conveyer is exposed. More objects are placed upon this within the frame, and a second radiograph is taken. This will be repeated, the first radiographs being developed while others

are being taken. The conveyer belt should be sufficiently long to allow the developed radiograph to be secured and examined with the corresponding original objects without disturbing the continuity of action of the machine. Each radiograph will have printed upon it the distinguishing character of that portion of the conveyer, and the different objects may be identified before they are disturbed.

A further modification of the invention may be made by utilizing the principles of the fluoroscope. In this form, in place of the sensitized medium would be used the ordinary fluoroscope screen, formed of any suitable material, as, for instance, the tungstate of barium or of strenium, in crystallized form, or barium platinum cyanide. The conveyer carrying the objects should in this case be placed between the X-ray tube and the fluorescent screen.

Having now particularly described and explained the nature of my invention, and in what manner the same is to be operated, I make the following claims therefor:

(1) The herein described process of examining separated matter or different objects, such as pearl oysters, in quantities, which consists in placing them upon a suitable support of a character that will not obstruct or only slightly obstruct the passage of X rays, Röntgen rays, or any other rays penetrating matter opaque to light; placing the sensitized medium below the support and exposing the objects and medium to the action of the rays; removing the support without disturbing the positions of the objects and then developing the sensitized medium, whereby a radiograph of the objects will be obtained, which can be compared with the objects without disturbing them.

(2) In an apparatus for examining matters or objects in bulk, the combination with a support for the objects, the said support being formed of material readily penetrable by the rays, and having upon it a distinguishing mark, made of material not penetrable, in combination with a means for producing rays.

(3) An improved tray, made of material which is of such quality and dimensions as will permit objects to be placed thereon and readily radiographed as though such tray had not been interposed between such objects and the sensitized medium.

(4) The combination with a tray of canvas (*c*) and a rigid frame (*a*) to which the canvas is stretched.

(5) The combination with the bottom and frame of a tray and a second frame above the bottom, the said second frame being for the purpose of keeping the matter which is examined a sufficient distance away from the first frame, in order that the rays passing through such matter will fall clear of the first frame and upon the sensitized medium.

(6) The combination with a conveyer and a frame of means for supporting the sensitized medium below the conveyer, and means for producing rays and securing a radiograph upon the sensitized medium.

(7) The use of a fluoroscope in connection with any form of device shown in the drawings or covered by the preceding claims.

In addition to having to devise a special method, of which the above is a description, it was necessary to adopt radiographic apparatus and materials of such a nature as to make the methods and costs of the process commercial. For instance, it was necessary to be able to make X ray exposures over a large area in order to include sufficient oysters at an exposure, an area larger than had been before attempted or rather required in the field of surgery, in which I found the use of the X ray exclusive when I commenced my investigations; also photographic material of a nature and cost suitable for the work had to be sought. Without going into details, I may say that I overcame the various difficulties, as I believe the accompanying exhibits prove.[a]

PRACTICAL DEMONSTRATION OF THE PROCESS.

After considerable correspondence, I went to Ceylon to start my enterprise, and established my equipment on the island of Ipantivu, in the northwestern Province of Ceylon, and near to the famous pearl fishery of the Gulf of Manaar. I have there invested in buildings, machinery, boats, equipment, and photographic supplies the sum of nearly $50,000, some of it my own money, but most of it subscribed by different people in smaller or larger amounts, to whom I or my friends had explained my ideas and the possibilities therefrom. I proposed to get oysters when they were freshly fished, and instead of indiscriminately killing all in order to get the pearls of value contained in the few, to subject the oysters to the process. Those found to contain pearls of value could be immediately opened; those containing small pearls of but little or no value, could be planted under suitable conditions to remain until they had become older and larger, and the contained seed pearls also larger and of value; while those found to contain no pearls could be returned to the sea either in

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[a] The following exhibits were appended to the manuscript submitted by the author:

Exhibit A, showing a part of the installation on Ipantivu Island—the water distilling building and chimney, the process building, and bungalow.

Exhibit B, showing a panoramic view of the installation.

Exhibit C, showing coolies arranging oysters in trays.

Exhibit D, showing coolies carrying trays of oysters up to the process building to be subjected to the X ray.

Exhibit E, a small radiograph of some growing oysters containing pearls.

Exhibit F, a small string of seed pearls.

Exhibit G, a radiograph of an oyster containing a seed pearl of a larger size and a string of pearls of which Exhibit F was a part. Note the line down the center of the pearls showing the drilling. Undrilled, in their natural state, these pearls would show up even more clearly.

Exhibit H, a part of a full-size radiograph showing some oysters containing small seed pearls.

Exhibit I, a full-size but only partly "fixed" radiograph of 120 oysters, showing number of tray made by lead number thereon, and arrangement of oysters in regular rows by means of which the oysters held on the trays are identified. The marks made by the inspector for seed pearls, large pearls, or obscurity, or for other things are also shown.

the hope that they would become inoculated with the pearl-inducing cestode or at least to propagate and maintain the growth of oysters on the banks.

The immediate objects in view were therefore—

(1) The prevention of the theft of pearls from the rightful owners of the oysters.

(2) A great increase in the yield of valuable pearls from a given number of oysters.

(3) The maintenance of the yield of oysters from the natural beds, if not a positive increase therefrom, as against the destruction of the fisheries under present methods.

In actual working the radiographs are brought wet out of the process building, wherein all exposure and developments are made in "dark-room" light, and with good light and the wet radiograph practically nothing can escape. It is easier to disclose that an oyster contains a pearl than actually to extract the pearl. If the process errs, it errs on the side of safety. We find that we set apart many oysters as containing seed pearls, which further examination shows contain none, but that what was shown in the radiograph was an imperfection in the film, an air bubble, a piece of coral outside the shell, etc. With practice, even these mistakes can be eliminated, but they are not of such a nature as to make us lose or eliminate an oyster which has the possibility of developing a valuable pearl. With sufficient and proper help and auxiliary appliances, the plant on Ipantivu Island, with its single tube equipment, can radiograph up to 400 oysters per minute. These thin-shelled, small Ceylon oysters (*Margaritifera vulgaris*) are easy to handle. But we can attain just as much success with the fresh-water mussels of the United States and other countries, and with the larger *Margaritifera maxima* peculiar to Australia, Burma, etc. In fact my first experiments were made on these. We can not, of course, do so many at a time or so quickly, as they require a longer time of exposure, but on the other hand, the product is of much greater value. My plant on Ipantivu Island has completely fulfilled all expectations, and, so far as concerns the possibility of radiographing pearl-bearing oysters on a commercial scale in order to disclose the contained pearls and without injury in any way to the oysters, has proved my process to be a complete success.

Unfortunately, owing to certain conditions which arose after I came to Ceylon and invested my capital, and which have prevented my getting live oysters, I have up to now been unable to prove the next and equally important stage of my process. However, as to whether pearl oysters known to contain seed pearls can be kept under such conditions as will make them continue to live and grow and thrive, and the majority of the contained seed pearls likewise to increase in size and consequent value, I leave it to the members of the International Fishery Congress to decide.

FUR SEALS AND THE SEAL FISHERIES

By Charles H. Townsend

Director New York Aquarium, New York City

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

FUR SEALS AND THE SEAL FISHERIES.

By CHARLES H. TOWNSEND,
Director New York Aquarium, New York City.

The history of the world's seal fisheries is largely one of wasted resources. Very few sealing industries have been conducted according to methods designed to perpetuate the race. Yet from a commercial point of view, seals are the most important of the carnivorous animals. As a group they are probably also the most abundant of the larger wild mammals at the present time. It is doubtful whether the herds of bison in America and of antelopes in Africa ever exceeded the seals in point of numbers. They are of world-wide distribution, and although the fur-seal fisheries of the North Pacific have received much international consideration during recent years, they were formerly not the only seal fisheries of importance. The pursuit was at one time carried on in the Antarctic regions as well as in the Arctic. The Antarctic sealing grounds have long been exhausted commercially, however.

All seals breed on land or on ice floes, and return, after their migrations, to their accustomed breeding places with great persistence. They can seldom be driven entirely away, stupidly lingering until brought near the point of extermination. So certain are they to return to their breeding grounds that the reestablishment of the different species soon follows the protection of these places. The safeguarding of depleted sealing grounds would, in fact, be a good business proposition even at this late day, if they could be protected under the authority of the various governments laying claim to such lands.

ANTARCTIC SEALS.

The various species of Antarctic fur seals (genus *Arctocephalus*) were found about the southern shores and islands of South Africa, Australia, New Zealand, and the islands of the Antarctic generally. About the close of the eighteenth century there sprang up a traffic in the skins of fur seals, and as the result of the many voyages to those distant regions enormous numbers of the animals were taken. By 1830 the supply of fur seals in the southern seas was nearly exhausted. The species exists to-day as mere remnants of the great herds that were once found in those regions.

In this sealing no discrimination was made in the character of the seals taken. All animals whose skins were of any value were slaughtered, and the newly born young, usually left on the killing grounds, died of starvation. In the rush to the Antarctic sealing grounds the markets were frequently glutted and much of the catch wasted.

The South African fur seal (*Arctocephalus delalandi*), frequenting small islands off the west coast of South Africa, became very rare from indiscriminate sealing. It has, during very recent years, been protected by the government of Cape Colony. The yield of skins from this source has been as follows: 1902, 1,300; 1903, 4,800; 1904, 7,400; 1905, 1,231; 1906, 12,640; 1907, 16,786; 1908, 13,649.

One resort of the genus *Arctocephalus*, the Galapagos Islands, lying on the equator, about 800 miles west of Ecuador, furnishes an especially striking illustration of wasteful sealing. These seals (*Arctocephalus philippi*) were taken in important numbers by early voyagers. Between 1870 and 1882 the rookeries were again visited by sealers, and, as far as shown by the meager records collected from the sealers still living who engaged in this fishery, about 20,000 seals were taken. This is of course a trivial number as compared with the total catch made during that period, the records of which are not available. Later voyages resulted in the killing of all the seals that could be found. At the time of my first visit to the Galapagos Islands, in 1888, I was informed that there were only a few seals remaining, and those about the uninhabited westerly islands of the archipelago.

It was a matter of great surprise when, in 1897 and 1898, a vessel returned to San Francisco from the Galapagos Islands with a catch of several hundred fur seals. It appears that the few that had escaped the slaughter of the last voyage, fifteen years before, had established themselves on the identical rookeries from which they had been driven, as comparisons of the log books of the vessels showed. Unknown to anyone, the nucleus of a fine herd existed there, which no doubt could have been developed into an important seal fishery if the fact had been known in time to prevent its destruction by raiders. It is probable, indeed, that a few individuals have escaped this last slaughter, and with the prompt protection of the rookeries by the Government of Ecuador a fishery could yet be established.

Another species of fur seal (*Arctocephalus townsendi*), the most northerly offshoot of the Antarctic race, formerly inhabited Guadaloupe and other islands off the west coast of Lower California. From the scattered records that have been found it appears that 15,000 seals have been taken there within comparatively recent years. (The earlier records are not available.) During the writer's visit to Guadaloupe, in 1892, straggling fur seals were observed about the island, and specimens obtained proved the species to be new to science. It

is possible that there is a sufficient remnant to warrant the belief that the race could be reestablished if the islands were properly protected by the Government of Mexico. The value of fur-seal skins taken in tropical or semitropical localities is, however, small as compared with those from cold climates.

In all the history of Antarctic sealing there is but one chapter of wise management and thought for the future: The Government of Uruguay has, throughout all these years, carefully preserved the fur-seal rookeries of Lobos Island, at the mouth of La Plata River, inhabited by *Arctocephalus australis*. These small rookeries illustrate the good resulting from the careful protection of the seals upon their breeding grounds. Commercial sealing was carried on at Lobos Island prior to 1820. The lessees of the island, operating under the direction of the Government of Uruguay, placed upon the London market, from 1873 to 1904, 377,033 skins, or an average of over 13,000 a year, worth in 1901 $100,000. All these were derived from a single island less than 1 mile in length. The following data show the yield of skins from Lobos Island during recent years: 1902, 12,922; 1903, 10,994; 1904, 8,349; 1905, 2,025; 1906, 8,398; 1907, 4,373; 1908, 2,990. The Lobos seals are now menaced by pelagic sealers, and some vessels have been seized by the Government of Uruguay.

In 1888, when in the Straits of Magellan, I found the fur-seal herds of that region nearly exterminated by the hunters working among the Fuegian Islands. The recent catch from what is called in the trade the Cape Horn region is as follows: 1905, 11,190; 1906, 13,628; 1907, 16,786; 1908, 8,262.

NORTHERN FUR SEALS.

The history of Robbin Island, in the Okhotsk Sea, is especially noteworthy. This island is about 600 yards in length and less than 100 yards in width, and yet incomplete records show that more than 60,000 seals have been taken there by raiders since 1870. A remnant of this herd has remained annually to repopulate the rookery, which at the present time contains little more than 1,000 seals and is protected by the Russian Government.

The scattered fur-seal rookeries in the chain of volcanic islands stretching northward from Japan, known as the Kurils, have also been destroyed by raiders during recent years. The history of the extermination of these seals, as furnished to the writer by men who engaged in the slaughter, is exceedingly interesting. Notwithstanding the fact that raids were made year after year, the scattered remnants of the herds still clung to their old breeding grounds. The incomplete records at hand show that more than 25,000 seals were taken from the Kuril Islands by raiders since 1880. These rookeries were visited by the United States Fisheries steamer *Albatross* in 1897, and all the rookeries were found to have been wiped out with the exception of one, upon which there

were about 100 seals remaining. It is believed that these will be protected by Japan, to which country they belong. The seal inhabiting Robbin Island and the Kuril Archipelago is now known as *Callorhinus curilensis*.

The only important strongholds of the diminishing northern fur seals to-day are the Pribilof and Commander islands, in Bering Sea. The species established on the Commander Islands is *Callorhinus ursinus*, while that breeding on the Pribilofs is *Callorhinus alascanus*. Although the two species breed upon islands lying in the same latitude and less than 1,000 miles apart, there is no commingling. The former migrates southwestward in winter along the Asiatic coast, while the latter migrates southeastward along the American coast.

Upon the discovery of the fur-seal islands of Bering Sea, more than a century ago, seals were found in great multitudes. For many years they were killed indiscriminately, but the Russian Government finally took charge of them and directed the fisheries in such a way that they were regularly productive. The Pribilof Islands in the twenty years after the accession of Alaska yielded more than $7,000,000, the price paid for the entire District. About twenty-five years ago the practice of pelagic sealing—the killing of seals in the open sea—developed into an extensive industry, since which time the supply of seals has steadily decreased.

Although during the winter months the fur-seal herds migrate into the Pacific Ocean, they are in summer located on their anciently established breeding places in Bering Sea. The fishery is conducted under government supervision, and a certain number of seals may be killed on the islands, selection being made in accordance with the natural habits of the animals. Fur seals are highly polygamous, and the rookery communities are divided up into harems. The males arrive at the islands and fight furiously for the possession of territory. The females, arriving soon after the males have established themselves, are divided up among them, in numbers varying from a dozen to a hundred to each male in extreme cases. This arrival occurs in June, and the young are born the last days of June or in the early part of July. The young seals remain with their mothers until the latter part of August. The seal herd lingers about the islands until late in the fall, when the annual movement into the Pacific Ocean takes place.

The highly polygamous habit of the fur seals naturally results in a large surplus of males, which surplus, when the rookeries were in their best condition, amounted to about 100,000 immature males a year on the Pribilofs and over 35,000 a year on the Commanders. These half-grown males herd by themselves, on so-called "hauling grounds" adjacent to each breeding rookery, and it is from them that the annual catch on the islands has always been made. The seals are quietly surrounded, and without difficulty are driven inland, entirely away

from the rookeries of breeding seals, as easily as a band of sheep. They are killed and skinned by the natives, the skins are counted by government agents, and are then placed in the salt houses of the lessees of the islands for a month's curing, when they are shipped to London, which has always been the world's fur-seal market. The selecting and killing are accomplished without noise or disturbance, and everything is done decently and in order. The United States and Russian Governments have never allowed any disturbing of the breeding rookeries and have never permitted the killing of female seals. The breeding stock upon the islands has therefore remained undisturbed, and would, but for the international nuisance of pelagic sealing, have yielded forever a world supply of sealskins.

Pelagic sealing, however, practiced in the open sea both in and out of season, permits of no selections being made, and the catch consists of young and old, male and female. By far the greater portion, however, is female seals, for these, after the young are born, go to sea to feed, ranging as far as 200 miles from the islands and returning at more or less regular intervals to nurse their young. The killing of females at this season is followed by the starvation of all nursing young on the breeding grounds, the loss of young in this manner corresponding with the number of mother seals taken by the sealing vessels. In ten years pelagic sealing in the adjacent waters and in the Pacific Ocean destroyed the value of the Pribilof and Commander islands as government properties. The seal herds are now so decimated that the surplus males available for killing on the Pribilof Islands are less than half as many as in 1896.

Pelagic sealing at the present time is engaged in by vessels belonging to British Columbia and to Japan. The British Columbia fleet has greatly diminished in numbers as the seals have become fewer and it found the profits less, but there has been an increasing number of Japanese sealers in recent years, until in 1908 the latter fleet numbered 38 vessels, which took 13,197 skins. The British Columbia fleet in that year numbered 8 vessels, and took 4,452 skins. This total of 17,649 skins is, however, a great decrease from the pelagic catch of 61,838 skins in 1894, and shows the results of the indiscriminate slaughter.

So long as pelagic or indiscriminate sealing in any form remains, the restoration of the fur-seal fisheries will be impossible. The Bering Sea controversy was precipitated by the seizure by the United States Government of Canadian sealing vessels in Bering Sea. Later on, the matter was placed in the hands of the Tribunal of Arbitration at Paris. This tribunal having decided that the United States had no jurisdiction over Bering Sea outside of territorial limits, pelagic sealing continued in but slightly modified form. Renewed efforts have been made by the United States Government to put a stop to it, however. American citizens, a small number of whom were engaged in pelagic sealing,

have been prohibited from engaging in the pursuit of seals at sea, and Congress has passed laws prohibiting the importation of skins taken by pelagic sealing into the United States.

The seals taken at sea are shot or speared, and the skins, thus injured, are consequently less valuable than the land catch. The class of skins obtained under government direction on the Pribilof and Commander islands is of the highest quality, the animals selected being 3-year-old males of nearly uniform size, killed when the fur is in best condition. This catch in 1908 amounted to 14,964 skins, which sold at an average of $30 per skin.

ECONOMIC CONDITIONS OF THE FISHERIES IN ITALY

By Guido Rossati

Representing the Italian Ministry of Agriculture, Industry, and Commerce

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

ECONOMIC CONDITIONS OF THE FISHERIES IN ITALY.

By GUIDO ROSSATI,
Representing the Italian Ministry of Agriculture, Industry, and Commerce.

Honorable PRESIDENT, LADIES, AND GENTLEMEN OF THE CONGRESS: It is a gratifying duty that I have to perform in thanking the honorable gentlemen who have welcomed us to this congress and the members of its organizing committee for the courteous invitation extended to Italy to be represented at this important gathering. I do so personally and in the name of the Government of Italy, whom I have the honor to represent. I can assure you that the Government of my country takes the utmost interest in this assemblage of eminent scientists and technical men, gathered here for the purpose of studying the multifarious problems connected with fishing and of promoting an industry which is probably the oldest to which man has applied himself for his sustentation. The Government of Italy attaches the greatest importance to this congress because it is in sympathy with the development of fish culture, and not only the Government but also the scientists of Italy will follow with great concern the labors of this congress, as is evidenced by the presence here of one of the best-known Italian authorities on the subject, viz, Prof. Decio Vinciguerra.

No better place for a fishery congress could have been chosen than Washington, the capital of a great and modern nation, stretching from one to the other of the two largest oceans of the earth and embracing a great variety of climates, which enable it to avail itself of a great diversity of sea food; traversed by numberless rivers, among them some of the largest in the world; containing some of the greatest inland water basins; a country rich in streams, bays, gulfs, inlets, where the supply of fish is so abundant; in brief, a land which combines so many natural advantages and favorable conditions for fishing as to be beyond comparison with any other part of the globe.

But there is another and yet stronger reason why the United States of America has attained preeminence in the fishing industry, and this is to be found in the fact that its people have sought and are continually striving for a better utilization of these natural factors of economic wealth, thus standing as an object lesson to other countries where the bountifulness of nature has not always been a stimulus to development and to the exercise of such effort as to

attain a high standard of progress. It is this exercise of endeavor to a constant betterment of conditions in all branches of human activity that characterizes this nation essentially, and it is this characteristic that most strikes the attention of foreigners when viewing the economic and social conditions of this country. It is this spirit which pervades the national life, the factor, quite as important as the natural wealth, that has brought the United States to the front in all lines of activity, and that makes it the object of admiration of all civilized countries.

To this well-directed and successful effort through the Government, associations, and private individuals, and to the splendid work of the American fisheries bureau and of the many stations, scientific laboratories, and aquariums, is due the fact that this country derives from the fisheries greater profit than any other, although it is only about half a century since the pursuit of fishing has been able to avail itself of the advantages of scientific research and discoveries—this itself a line of work in which American talent and ingenuity have probably many followers, but none surpassing them. Owing to these conditions we come to this congress as to a school from which we are certain we shall go away greatly enlightened.

The country which I have the honor to represent has since time immemorial occupied itself with the pursuit of fishing. The lacustral inhabitants of northern Italy who had built their homes on the lakes in order to attain the conditions of safety that were essential to their social life must unquestionably have been fishermen. We learn from ancient historians of people living on the shores of the Mediterranean who were great consumers of fish. Sea food figured prominently in the fare of the ancient Romans, especially in the great dinners with which Lucullus, Hortensius, and other Roman amphitryons used to delight Roman society during the golden period of Latin history. We have all read about the "muræna," a favored dish with the Romans, and which, according to an ancient writer, had to swim three times—in water, in sauce, and in wine—a habit of swimming which fish still preserve to-day. That the Romans favored fishing, notwithstanding the primitive methods by which it must have been carried on at that time, there is no doubt, for we know that sea food entered largely into the diet not only of the rich but also of the plebeian classes. Moreover, we can not peruse the Georgics of Virgil or the Metamorphoses of Ovid without meeting frequently with references to the inhabitants of the deep. The advice of Ovid, "Semper tibi pendeat hamus quo minime credas gurgite, piscis erit" (Let thy hook be always ready, as a fish will often be in waters where thou least thinkest of it), is in both fishing and common life still of up-to-date application.

During the middle ages and the troublous times which characterized that period of Italian history, the Church, which had built on the ruins of the Roman Empire a new order of things based on Christian teachings, became the patron

of the fishing industry chiefly by reason of the dietetic precept of abstinence from meat during certain days of the week which it imposes on its followers; and we are reminded of the fact that the Church was established by a fisherman, and that several of his colleagues were of the same calling. It is undeniable that the Church exercised a favorable influence on the industry of fishing, which flourished and received further stimulus when Italy, under the republics of Venice, Genoa, Pisa, and Amalfi, which were essentially maritime states, began to send fishermen all over the Mediterranean and found in fishery the most efficient and practical school for raising a population of able seamen, to whom is essentially due the greatness acquired by those famous republics.

Even to-day Italy maintains preeminence in fishing in the Mediterranean, which is due to the Italian labor engaged in this industry. Italian fishermen are to be found all along the coast of Algeria, Tunis, Tripoli, the eastern shore of the Adriatic, and in the Greek Archipelago, often engaged in the most dangerous and varied forms of fishing, whether it be spearing the swordfish in the Messina Straits or plunging into the waters surrounding the Lampedusa Isle in search of sponges, trapping the tunny-fish on the western coast of Sicily and Sardinia, netting the shoals of sardines on the coast of Tuscany, or exercising themselves in the ingenious methods of coral fishing on the north African coast; all of which are special branches of fishing in which the Italians have attained great proficiency and enjoy a world-wide prestige and demand. They are also the support of important industries, such as the canning of tunny-fish, sardines, and anchovies, which find natural facilities in Italy's large production of the olive oil required in their packing.

Italy, however, with a seashore extending over 4,300 miles and a population of about 115,000 men that derives its means of livelihood from the sea, manning about 24,500 fishing boats, has a yearly output of fresh fish representing a value of only about 22,000,000 lire. Even allowing for the imperfection with which the statistical data are gathered, considering the great extension of her shore and the great amount of labor engaged in this pursuit, these figures show at once that the fishing industry in Italy, however traditional and assisted by the natural inclination of the people to it, is still far behind the reasonable expectations of the country, especially from the standpoint of the profit that the fisherman derives from his industry, which is unfortunately lower than in any other important country of Europe.

The cause of these conditions, which make the task of the fisherman in Italy a rather thankless one, is not to be found in any want of activity or energy on his part, but to circumstances over which the husbandman of the sea has practically no control and very little means whereby to better things. Such are, for instance, the much discussed depauperation of fish in the waters where he exercises his activity, accentuated by the fact that no tentative effort has yet been made in Italy with regard to the restocking of maritime waters with fish;

what has been done in this direction being confined to the restocking of inland waters with choice species, where the conditions of the industry are perhaps enjoying the advantages of greater attention. This is not surprising considering the fact, almost general even in the most progressive fishing countries, that fishing on inland waters is much easier and not fraught with the uncertainty and perils of the sea, and is therefore assuming every day more of a cultural character, the pisciculturist cultivating the water as the agriculturist cultivates the soil for the feeding of man.

But, returning to maritime fishing, the main reason why Italy does not make a better showing in its results from an economic standpoint is the primitive methods by which fishing is still carried on, entirely by small sailing craft, which in other countries have been largely supplanted by motor power to propel the boat and operate the nets. Then, the absence of proper organization and intelligent cooperation, which are necessary factors to secure a prompt and wide distribution of such a perishable article as fish, is another cause. Steamboats to carry the catch promptly to distributing ports; good landing facilities and a quick and well organized railroad service to expedite the delivery of the fish to the markets in the shortest possible time; an intelligent application of the use of ice and refrigerating plants in the transportation, preservation, and distribution of this perishable commodity; cooperative action among fishermen in order to secure to themselves the highest percentage of the profit deriving from their labor; credit within easy reach and at a moderate rate of interest to fishermen; elimination of octroi duties and the fiscal dues which at present handicap this industry—these are some of the essentials for rehabilitating its destinies.

Besides maritime fishing, Italy is greatly interested in inland water fishing, its numerous rivers, lakes, and lagoons suitable for this purpose occupying practically one-eighteenth of the surface of the Kingdom. Filippo de Filippi, a noted Lombardian zoologist, who was the pioneer of fish culture in Italy, stated that if there is a country favorably laid out by nature for the development of inland fisheries it is certainly the Valley of the Po.

Notwithstanding the inherent love of the Italian gentleman for angling, evidenced by the fact that there is no villa of any importance in Italy not provided with a "pescheria" where fish are raised, not for sale but for the private use of the owner who can exclaim with Carew—

> Thus mean in state and calm in sprite
> My fishful pond is my delight—

fishing in fresh water is probably in not much better condition than the maritime industry, and the value of the annual output of inland fisheries in Italy does not exceed 6,000,000 lire.

We have no special statistics to show what is the value of the fish taken from lagoons or estuaries, where fishing is an art that has engaged the attention

of the adjacent population from the earliest times. This blank in the Italian statistics is all the more deplorable as it is unqestionably from this source that a good deal of revenue from the fishing industry is derived. Of what importance these lagoon and delta fisheries, in Italy comprehensively called "vallicoltura," are to a considerable number of the Italian population may be seen from a glance at the hydrographic map of Italy showing the considerable extent of the Venetian lagoon, famous for its mullets; of the Valli di Comacchio, formed by the delta of the Po, where the eel, sung by Ariosto and Tasso, is the staple of fishery; and of the Mare Piccolo of Taranto, noted for its oyster beds, already celebrated in antiquity as were the esculent bivalves from Lakes Fusaro and Lucrino, which the Parthenopean siren offers to the visitors with the allurements of White Capri.

It is the fishing on inland waters that has received the greatest attention on the part of the Government, although even sea fishing has not been neglected, at least from the standpoint of legislation. With the progress of hydrobiology, a science which has developed practically within the last fifty years and to which the genial labors of such men as Spallanzani, Rusconi, Canestrini, Issel, and other Italians have largely contributed, dates the action of the Government to the fostering of this branch of national economy.

The lines upon which governmental action has been directed to the promotion of the fishing interests are summarized in the following paragraphs:

First. The policing of maritime and inland waters in order to discipline the catching of fish by prohibiting fishing during the time of the spawning and reproduction; by fixing the minimum distance from the seashore where fishing is allowed, as well as the depth at which fishermen may lower their nets; by establishing the kind and quality of the nets and the minimum size of fish that is allowed to be marketed; by prohibiting the use of explosives and poisonous materials in the catching of fish, and also the use of undesirable fishing apparatus; all of which disciplining is done according to the dictates of science with a view of regulating the supply, its continuance and increase. The enforcing of the laws and regulations on fisheries (the fundamental one of which dates from 1877) is intrusted to the captaincies of the ports, to the custom-house officers, to the officers of the royal navy in the case of maritime fishing, and to forestal officers, local police, and custom officers in the case of inland waters. Unfortunately this policing of fisheries in Italy leaves yet much to be desired in its application, and the law is frequently violated with great loss to the fishing industry, both through the incentive of illegitimate gain, and in a good many cases also through mere ignorance. Hence the necessity of insisting upon a greater spread of knowledge among the masses of the people regarding the habits of fish, the time and way in which their reproduction take place, migrations, and all technical information which may be conducive to greater enlightenment on the subject. This would be the best measure of prevention against damage often done through sheer ignorance.

While, of course, the necessity of laws and regulations disciplining fisheries in order to maintain their productiveness is unquestionable, we believe, nevertheless, that instruction and education are also great factors in preventing abuses and reaching a better standard. Instruction to this effect ought therefore to be imparted to the people at large in elementary and secondary schools, and this without speaking of the necessity of greater education along these lines to those who will be called upon to exercise their activity in the economic life of the nation.

Second. In having established advisory bodies, such as the Central Consultative Commission for Fisheries and compartimental commissions subordinate to the former, operating in the four or five maritime districts in which the peninsula has been divided for this purpose, and in having established besides provincial commissions on fishing. There are altogether about 25 such bodies.

Third. In having created three piscicultural stations, one at Brescia, another at Belluno, and a third at Rome, the latter in charge of Professor Vinciguerra, whom we have the pleasure of seeing at this meeting. These stations are intrusted with manifold duties, the principal of which is the incubation of the spawn and raising of the fry wherewith to provide for the repopulation of inland waters with fish of choice variety, and I am glad to state in this connection that millions of fry have been introduced of late years in the principal lakes and rivers of Italy, among the new varieties introduced being several American species of trout and whitefish. The directors of these stations are also required to give periodical lectures on fish culture and to spread useful information in regard to the industry. It is superfluous to state that the results obtained have been excellent, when the comparatively small appropriation for their sustenance is considered, and their action bids fair to exercise a deep influence in the revival of fish culture in Italy. The Government has also in late years, with the cooperation of local bodies in Venice, established a school for fishermen and for the preparation of technical men, which has supplied a want that had indeed been long felt and which has already accomplished much good in organizing the fishermen of the Venetian shore for a cooperative method of work. Courses of biology in connection with fish culture have also been instituted at the universities of Rome and Messina and at the Agronomical Institute of Milan, and have become popular among the students.

Fourth. In having provided money prizes and awards in medals for encouraging cooperation among fishermen and rewarding the efforts of any society or private party endeavoring to foster the interests of fish culture in the Kingdom. The action of the Government has been ably seconded by such bodies as the Società Lombarda per la Pesca e l'Acquicoltura, Società regionale Veneta per la Pesca e l'Acquicoltura, and Società 'Aaliona per la Pesca.

It is to the concomitant efforts of the Government, of technical institutions, and of men such as Pavesi, Carazzi, and others that a greater interest is

being taken to-day by my country in developing the resources of its waters, an interest which will eventually lead to larger appropriations from the national treasury for aiding this industry in a way more adequate to its possibilities and requirements.

Hydrobiology and its recent discoveries have opened new horizons to the possibilities of what has been comprehensively called "water culture." The natural depauperation is being remedied with the restocking in all waters inland, where new fields of fishery are suggested, such as the raising of carp in rice fields, as well as in the sea, evidenced by the restocking of the fjords of Norway with the eggs of the codfish.

The importance of the plankton to fish life, of the flora and fauna living on the borders and in the bottom of waters; the relation of temperature to the inhabitants of the deep, which has suggested in certain localities the application of the thermometer to fishing; the relation of the chemical composition of water and of its greater or lesser saltiness to the population of the seas; the pathology of fishes, the application of artificially promoted diseases to obtain industrial results, such as the grafting on the pearl-producing oyster of the parasite which is the cause of the formation of the pearl, an original suggestion by Professor Issel of Italy and utilized by Herdman on the waters of the Ceylon island; the habits and various stages of life of different fish having partly a pelagic and partly a fresh-water habitat, such as the eel; the prevention of the inquination of waters from the refuse of industrial establishments; the reforestation of lands to prevent muddy waters that are prejudicial to the life of delicate fish—all these subjects are to-day far better understood and studied than ever before, not only by the general scientific world but also by progressive ichthyologists.

Although the "cultivation of the water" is a far more difficult problem than that of the solid crust of the earth, not only because of the greater perils with which the former is identified, but also because we are less acquainted with the conditions of existence of the animals which populate the water, still it is one of those problems the importance of which the future will make even more evident and impellent. The preoccupation manifested years ago by Sir William Crookes with regard to scarcity or insufficiency of the staple of life confronting humanity in a near future need not engross the minds of economists, because it will find its natural solution in the increased rate of production of wheat which is within the sphere of reasonable possibilities, and also because human ingenuity, as the population of the earth increases, will develop other sources of supply of food. If in the past humanity has called upon the earth for its main sources of sustentation, the humanity of the future will call upon the water in a more intensified form for this need; and the "intensive cultivation of water" as well as of the earth will be a conquest probably not so remote as we may believe.

The contribution that Italy has already given, and I hope will be able to give in the future in greater degree, toward this desirable end is and will be

notable, judging not only from the standpoint of the eminent services which her scientists have rendered to the progress of this, as well as of many other branches of activity, but also from the viewpoint of the aid that her seamen will give in the domain of the multiform energies of the water. Those fishermen who, through no fault of their own, can scarcely make a living on home waters, you will find industrious and prosperous where natural and economic conditions have been more generous to humankind. And thus you see Italian seamen controlling fishing in several parts of this country, such as certain parts of the Pacific and the Florida coasts.

Hence the importance that Italy attaches to this congress, in which she is taking more than a passing interest, for the promotion of American fisheries means also the promotion of the interests of a large class of countrymen of mine engaged in this field; and the best wishes for the successful labors of this congress, the result of which I shall report to my Government with that satisfaction that comes not only from the acquiring of new knowledge, but also from the certainty that this new knowledge will be highly beneficial to all countries interested in the exploitation of the waters.

THE FISHERIES AND THE GUANO INDUSTRY OF PERU

By Robert E. Coker

Lately Fishery Expert to the Government of Peru

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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THE FISHERIES AND THE GUANO INDUSTRY OF PERU.

By ROBERT E. COKER,
Lately Fishery Expert to the Government of Peru.

I. THE FISHERIES.

Doubtless the fishes and the fishery resources of no country represented at this congress are less known to the world than are those of Peru. That the resources are unstudied is not attributable to their inadequacy or to the failure of the people of Peru properly to value them, for Peru possesses a wealth of certain valuable forms, and no people could be more highly or more generally appreciative of fish food; nor is it because they have any recent origin that the industries are little known. In fact, there is reason to believe that centuries before the Columbian period the occupation of fishing was pursued in Peru, not simply as an unorganized food hunt, but as an important industry. Therefore neither the natural conditions nor the nature of the people can account for the scant knowledge of the fishery resources or the inadequate state of the industry. The explanation is found rather in the unfortunate history which has burdened the country since the overthrow of an earlier social and industrial life. It is only recently that a stable government has been able to give serious and effective attention to the many phases of industrial life of the nation, and to include in its many endeavors the effort to conserve and develop the valuable resources of the sea.

CONDITIONS AND RESOURCES OF THE REGION.[a]

The traveler from the north has his first glimpse of the coast of Peru as the steamer, after passing down the Guaya River from the chief port of Ecuador, enters the Gulf of Guayaquil. The steamer may, as sometimes happens, touch at

[a] For the scientific names employed in this report I am indebted to those who have kindly identified the specimens collected in Peru: Dr. Barton W. Evermann and Mr. Lewis Radcliffe (fishes), Dr. W. H. Dall (mollusks), Miss Mary J. Rathbun (crustaceans), and others.

A forthcoming series of systematic papers by various writers will give a comprehensive view of the chief aquatic resources of Peru as far as known at present. For detailed information regarding the methods of fishery, as well as the conditions and resources, reference is made to various reports by the present writer in the "Boletin del Ministerio de Fomento," Lima, vol. v., no. 12, Dec. 1907; vol. vi., no. 2, 3, 4, and 5, Feb. to May, 1908, and others in press.

the port of Tumbes, well known as the landing place of Pizarro. If so, the first impression of Peru is that which may have been anticipated of a tropical latitude—a region of thick vegetation, chiefly mangrove trees in swamps intersected by narrow winding estuaries, and traversed by a permanent river of considerable volume. The local conditions are similar to those that prevail in the neighboring territory of Ecuador. Naturally in such a region there is an abundance of shellfish, including oysters and many species of clams and crabs.

Typical, however, as this Tumbes region may seem for the latitude (3½° S.), and fitting perfectly to the region lying northward, the locality is entirely unique for the coast of Peru. About 20 miles beyond the territorial line the aspect of the shore presents the sharpest change. As the southern limit of the delta of the Guaya is passed, the green luxuriance disappears abruptly to give place to shores of barren and desolate appearance, and this new aspect continues practically unchanged for the remaining 1,400 miles of the Peruvian coast, and onward, in fact, into the domain of Chile. (Fig. 1, pl. XII.)

The type of coast characteristic of the country is, then, the reverse of what one might expect of a tropical region. With shores rainless and barren, a most significant feature is the practical absence of large rivers emptying into the sea or mingling with the ocean waters in coastal sounds or bays. The portion of the country west of the lofty western cordillera, the watershed of the continent, is a steeply sloping desert interrupted by the narrow valleys of numerous little rivers formed from the melting snows of the Andes. In the cooler season (May to September) the scant waters of these precipitous streams are soon exhausted by natural evaporation or seepage, or spent in the irrigation ditches of the fertile valleys. On the other hand, although in the warm period of November to March the melting snows swell the rivers into torrents, the coast at this time is enduring its driest season, and the soils and irrigated farms are making their greatest demands upon the rivers' flow. Such portion, then, as may eventually reach the coast in any season can form but a small lagoon, and this may be quite separated from the ocean by a narrow levee of shingle, which the surf builds up against the river. The mouth of the Rimac offers a good illustration of this interesting type of river mouth, across which one may walk dry-shod. (Fig. 2, pl. XII.) Beneath one's feet the lagoon empties gradually into the ocean through the loose formation of water-worn stones. Only in times of excessive flood is the levee actually broken through to form a visible mouth.

It is unnecessary to point out the significance to the fisheries, or to the natural history of the coast, of this general absence of estuaries, sounds, or brackish bays, such as would offer a quiet breeding ground for some kinds of ocean fishes, or afford a favorable environment for oysters, clams, and other valued shellfish.

No fishes ascend the upper courses of the rivers and the very few species found in the lower parts are very small and of negligible economic value. These little rivers are of great importance to the fisheries, however, as the habitat of the most important shellfish of the country, the excellent "cameron de rio."[a] This fresh-water shrimp is a most highly and deservedly prized product, the equal in quality of any crustacean form. The rivers are also significant, since in the time of flood the most important of the food fishes, the large "corbina," is found in greatest numbers in the neighborhood of the mouths, probably feeding upon the small crustacea which find their way out of the river. The season of "agua nueva" (new water) is a propitious one for the fishermen.

Consequent upon the absence of large rivers and the steepness of the coast, there are few good bays or harbors. Most of the ports are upon a more or less exposed shore, where embarkation must be effected through the surf, unless a long pier has been built out beyond the ordinary breakers. Even in comparatively calm weather, the great swells rolling into the open bays often assume such proportions as to make landings impracticable even with the use of long steel piers. Fortunately, the coast is entirely free from storms; but the fisheries as well as commerce are seriously handicapped at such ports as Eten, Salaverry, Cerro Azul, and Mollendo, where for days at a time communication between sea and land is rendered impossible by the prevalence of "la mar brava" (the wild sea).

Untropical as is the coast of Peru in its aspect as described above, it is equally so as regards the temperature of the ocean water. There is no more significant feature of the coast than the Humboldt or Peruvian current which flows northward and northwestward along the west coast of South America, bringing the cold antarctic waters down to the equatorial region. To find upon the coast of the United States a summer temperature of the ocean water corresponding to that of Callao at 12° S. one would go to about the latitude of New York on the Atlantic side (41° N.) or Monterey on the Pacific (36° N.). The Peruvian current, in conjunction with other factors, particularly the constancy of the winds on the coast, produces a relative uniformity of temperature conditions. There is little variation in the water temperature from hour to hour during the day, little difference from month to month during the year, and a relatively small change from latitude to latitude. It is probable that such variations as are found are due more to very local conditions, or to the swinging of the current, than to seasonal changes or differences of latitude. At Callao (12° S.) the water in early summer was at 15–19° C. (59–66° F.) and in early winter from 16.5 to 19° C. (61–66° F.); at Paita (5° S.), in April, records from 15.5° to 20.5° C. were taken, with an average of 17.5° C. (63.5° F.);

[a] *Bithynis cæmentarius gaudichaudi* (Milne-Edwards).

while at Mollendo (17° S.), more than a thousand miles to the south—or as far away from Paita as New York from Miami, Fla.—the midwinter temperature was 16° C. (61° F.). This current leads the fishermen to go southward from the port instead of northward, if a prompt return journey is desired, and its supposed swinging movements are of further significance, as it causes certain pelagic fishes to approach or recede from the coast.

With such low-water temperatures a tropical fauna is, of course, absent. Corals are wanting, sponges nearly so, and the general character of the fauna and flora of the region is such as would ordinarily be found in much higher latitudes.

In contrast to the barrenness of the coast there is a peculiar wealth of certain forms in the open ocean. The great red seas, formed sometimes, at least, of myriads of microscopic dinoflagellates, are of common occurrence. They are of uncertain value and sometimes seem to work much injury. Sometimes, too, great areas of the surface of the sea are reddened by the vast numbers of small crustacea (*Munida*), which then play a part of great importance as food for the fishes and for the guano-producing birds. More striking still are the immense schools of small fishes, the "anchobetas" (*Engraulis ringens* Jenyns), which are followed by numbers of bonitos and other fishes and by sea lions, while at the same time they are preyed upon by the flocks of cormorants, pelicans, gannets, and other abundant sea birds. It is these birds, however, that offer the most impressive sight. The long files of pelicans, the low-moving black clouds of cormorants, or the rainstorms of plunging gannets probably can not be equaled in any other part of the world. These birds feed chiefly, almost exclusively, upon the anchobetas. The anchobeta, then, is not only an article of diet to a large number of Peruvians, and the food of the larger fishes, but, as the food of the birds, it is the source from which is derived each year probably a score of thousands of tons of high-grade bird guano. It is therefore to be regarded as the most valuable resource of the waters of Peru. No more forcible testimony to its abundance could be offered than the estimate, made roughly, but with not wide inaccuracy, that a single flock of cormorants observed at the Chincha Islands would consume each year a weight of these fish equal to one-fourth of the entire catch of the fisheries of the United States.

The fishing grounds and opportunities, especially with the methods of fishery now in use, are restricted by the scarcity of good bays and by the rapid deepening of the water off the shore. Yet there are compensatory features. In proximity to almost every port are groups of islands, often with numerous coves and abundant outlying rocks, which offer a varied home for many species of rock and shore fishes. Along the coast proper some of the same species are found, with a good representation of the drums, the lizas, the flounders, and silversides.

To mention the most esteemed and important fishes:[a] The "peje-rey" or silverside (an atherinid), the most delicate of all fishes, is most easily taken in early or mid winter when it is depositing its eggs upon the algæ near the shores; the "corbina" attains a size of 30 or 40 pounds, and from its abundance and fine quality is the fish of first rank in importance; the "liza," or mullet, and the "lenguados," or flounders, are also of the first class. Yet perhaps none of these is superior to the congrio (representative of the Ophidiidæ), which is not commonly taken except in the southern part of Peru. Nearly a hundred food species could be mentioned, but only two or three more of these deserve mention for special reasons.

The bonito, though poor in quality, is, from its abundance and cheapness, the fish most available to the poorer people. The anchobetas (*Engraulis*) are favored by the indigenous Peruvians. Large quantities are preserved in the crudest way by mixing with salt and spreading on the ground to dry in the sun. They are then sacked to be sold at a small price ($1 the sack, more or less). This little fish of manifold uses is all the more significant because of the rare opportunity it offers for the preparation of an excellent preserved product—an opportunity that is not now utilized.

The selachians (sharks, rays, guitar-fishes, and angel-fishes) are not in most countries accounted important food fishes. But they occur in remarkable abundance in the northern region of Peru, where they are freely used and esteemed by the indigenous population. Just northward of the Peruvian waters our steamer passed for hours through an enormous aggregation of various kinds of selachians, the great giant rays, and sharks of all sizes, hammer-head and sharp-nose. On one occasion, in December, 1907, the beaches of the island of Lobos de Tierra seemed literally fringed by the protruding fins of sharks basking in the shallow waters.

The preparation of such fishes by drying them in the sun constitutes an important industry for the fishermen who frequent the island of Lobos de Tierra during the season when it is not closed for the protection of the guano birds. This island, unlike the others of the coast, is surrounded by sand bottoms favorable for net fishing. It is only 10 miles from the coast, but about 70 miles from the nearest fishing ports (Eten, Sechura). The fishermen form a camp here, coming out with their families in balsas (Sechura) or balandras (Eten, Paita). All kinds of fishing are pursued, but the most characteristic is the use of large-meshed nets of strong material for the capture of selachians and large flounders. The skillful manipulation of these fishes for preservation with or without the use of salt merits special description in a later connection.

[a] Peje-rey, *Basiliehthys jordani*, etc.; corbina, *Sciæna gilberti* Abbott; liza, *Mugil cephalus;* congrio, *Genypterus blacodes;* bonito, *Sarda chilensis.*

Naturally a coast like that of Peru does not offer a favorable environment for many kinds of the better shellfishes. The scallop[a], "concha abanico," "senorita" or "conchita," as it is variously called, is, however, very abundant in many places and often attains a large size. It ranks next to the freshwater shrimp, the "cameron de rio." Mussels, beach clams, the spiny lobster,[a] and various crabs are found in the market, but quite irregularly. The small region about the port of Tumbes in the extreme north is as unique for the coast of Peru in its fishery resources as in its physical features. From the mouth of the Tumbes River to Capon, near the Ecuador line, there is a network of salt and brackish estuaries in which thrive a variety of crabs, clams, and mussels. But the chief resource of the region is the abundant oyster,[a] which grows attached to the roots and branches of the mangrove trees margining the salt creeks (fig. 3, pl. XIII). The fishery for oysters is very restricted at present, but there is undoubtedly a fair opportunity for its development.

An allusion should be made to the pearl fishery which, in 1900, was exploited in the region from the Bay of Sechura to Paita. It appears that at the start the fishery was a success, but after a very brief period ceased to yield, and subsequent efforts failed entirely to locate any banks of pearl oysters. It is possible that the discovery of these beds awaits only the prosecution of a systematic investigation with deep drags or by diving. The "pearl oyster", or "concha perla" of the region is *Pteria peruviana* Reeve, the shells of which may not infrequently be found upon the beaches.

Perhaps in no other country is fish food more generally esteemed and used when available. So we find that not only the usual edible fishes and larger crustacea and mollusks, such as have been mentioned, but a wide variety of smaller and less generally esteemed forms are sought and prepared for the trade. In some parts of Peru there is hardly an available shore form that is not taken to be used as food. As articles of diet, we should include some species of sea weeds, the *Hippa*, hermit crabs and barnacles; the conchs, large and small; the crepidulas, patellids, fissurellids and chitons; the excellent sea-urchin and the sea-cucumber; the sea-anemone and ascidians—or almost everything of suitable size except annelids and jellyfishes.

Along the entire coast a considerable element of the population finds its support in taking fish for personal use and for the trade. In the larger ports the greater part of the product is eaten in fresh condition, but at other places where the fish must be conveyed a greater distance to port, or distributed over a wider territory on land, the fishermen salt or dry their catch by methods adapted to their means and knowledge.

[a] Scallop, *Pecten purpuratus* Lamarck; spiny lobster, *Panulirus ornatus* (Fabricius); oyster, *Ostrea chilensis* Philippi and *O. columbiensis* Hanley.

HISTORY AND PRESENT STATE OF THE FISHERIES.

Many of the present methods employed in the capture or preservation of fishes probably date back to a very remote time; for it is interesting to note that Peru not only claims an ancient fishery but offers some evidence to indicate that centuries ago the fishery and related industries had a relatively high degree of organization. The interesting story is often told of the system of transportation of fresh fish from the coast to the royal home in Cuzco, a region where fresh sea fish is never available now.

Through the earliest writers we know of the appreciation and use by the earlier Peruvians of the guano deposits of the coast for their great agricultural industries. The rigorous edicts for the protection of the guano-producing birds were evidence of admirable foresight and antedated by centuries any further effort to preserve the birds. Relics of pottery and gold are found buried in the sand or in the guano, and it is an interesting fact that modern explorations upon the coast and islands indicate that the villages necessarily supported by the fishery or guano-working industries possessed a degree of wealth that could have resulted only from an industry of relatively high development.

The great shell heaps and the islands and causeways of shells in the estuary region of the Gulf of Guayaquil testify to an early fishery of oysters and clams pursued in no rude or half-measure way. A thousand years of the present oyster fishery would not leave a trace comparable to these.

In short, it is probable that the ancient Peruvians were as competent in the fishery as in agricultural, textile, and other industries. Nevertheless, whatever may have been the condition in this earlier period, this industry, like all others, certainly fell to a very low stage after the conquest. During the past few years new fishermen have come in, new methods have been introduced, and better facilities have appeared; and yet the industry is but poorly developed, and its condition is distinctly unsatisfactory.

In attempting to give a brief account of the fishing industry as it is now carried on, it is not necessary that modernly introduced methods should receive more than the mention. It may be of value, however, to speak more fully of those forms of fisheries which may be presumed to have continued in use since the pre-Columbian period—those which are not borrowed but are actually and historically "home industries."

FISHING CRAFT.

It would seem natural that a people who could construct magnificent buildings and walls of stone that endure to our present admiration, would have fashioned good wooden boats, if the forests of timber had been available; but with the coast region desert and barren except for the scrubby growth of algaroba, with its dense and heavy wood, the ordinary materials of boat construction

were absent. A resourceful people found a substitute for wood in the reeds growing thickly near the rivers; bound together in sufficient numbers, these were made into remarkably strong craft which continue even now to serve a useful purpose. The "caballito" (fig. 5, pl. XIV) in its simplest form, as now used at Pacasmayo, for example, is made of two long bundles of "totora." The reeds are individually weak and flimsy, but the bundle, which is well wrapped with twine, is strong and comparatively stiff. Each bundle is about a foot in diameter at the aft end; forward it enlarges a little, and then tapers to a point at the other end. The two bundles are securely bound with rope, and the long tapering ends curve upward in graceful form. At a short distance from the stern (about one-fifth of the entire length) the inner and upper reeds of each bundle terminate squarely to form the forward end of a small pit, where the fish may be kept. The pit, which is about a foot deep at its forward end, rises gradually to the top of the caballito near the stern.[a] The craft derives its Spanish name of "caballito" (pony) from the method of its use. The fisherman sits astride, just forward of the pit, with his legs hanging in the water or resting on the side of the boat. For a paddle he uses a plain split of bamboo cane, paddling with each end alternately. With its shapely taper and upturned pointed end, the caballito, mounted by an Indian fisherman, not only presents a picturesque appearance, but is most serviceable for use in the short swell near the beach where an ordinary boat would be unwieldy. With his caballito anchored just beyond the surf, the fisherman sits just in front of the pit and facing astern. Of the three lines in use, two are attached to his belt while the third, which is stout and carries a large hook, is secured to the caballito. If both hands are busy with one line, the other is held with the toes. The fish must be killed with a small stick before being thrown into the pit, from which they might easily escape if alive.

The caballito is also used in net fishing. The net is in the form of a very large small-meshed bag which when in the water is kept open by gourd buoys attached to the top of the mouth on each side and by stone sinkers on each side below. The mesh may be 1½ to 2 centimeter bar. Extending outward from each side of the mouth is a "brazo" (arm) of some 8 fathoms length and of very large mesh. To the ends of the arms are attached the hauling lines. The fishermen astride of their caballitos haul this net through the water to take a school of "sardinas" or other fishes, all the time making as much noise in the water as they can with feet and paddles. The same type of net may be worked from canoes or flat-bottomed boats. (Pacasmayo, Chimbote).

The totora reeds may be bound together to form a much heavier and larger craft than the caballito. The "balsa" of Cerro Azul is made, like a raft, of

[a] Dimensions of a caballito: Length, 4.50 meters; width at stern, 0.56 meter, stern to forward end of pit, 0.94 meter; depth of pit, forward, 0.30 meter.

three logs well lashed together, but each log is only a bundle of totora, which tapers slightly toward the forward end, where it is gently curved upward. The diameter at the stern is about 25 centimeters. The bundle consists of an inner core or heart ("corazon") and a thin outer shell, so that as the exposed reeds decay under the action of the water and the sun they may be removed and replaced without disturbing the entire balsa.

The most elaborate boat of reeds[a] is the balsa used in Lake Titicaca, where it is fashioned in a more boat-like form. (Fig. 6, pl. XIV.) The squarish sail is woven of the same reeds and somewhat in the fashion of a Venetian blind. These balsas are broad, and excavated so that they may accommodate an entire family bringing their various products to market. Though we are not at this point immediately concerned with the fisheries of the lake, an allusion should be made to the use of these totora reeds in the construction of fishing weirs. At the small end of the funnel-like weir there is set a net fixed on a conical framework of poles which can be raised or lowered from the balsas.

These boats of reeds could not have sufficed for the longer fishing voyages and the commerce from port to port, but this need was supplied by the introduction of the balsa wood growing in Ecuador. This exceedingly light wood possesses the merit of not absorbing water, so that it will float indefinitely. From these logs, rafts or balsas are constructed in all sizes, from the small ones of about 6 feet length to the large 30 or 40 foot balsas, which have an upper deck and are fitted with a large squarish sail. On these the Indians with their families will live for weeks. The fishermen of Paita and Sechura find their most profitable fishing grounds about the islands of Lobos de Tierra or Lobos de Afuera, at distances of 70 to 100 miles from port. Living on the commodious balsas, the fishermen navigate along the coast, fishing where it is desirable, or moving to their camps on the islands, to remain until a cargo is salted away.[b]

Some type of canoe is found at every port. Most of these are made from wood brought from the region of Guayaquil. "Canoas" of the commoner woods are said to last only a few years; "figaroa" is a much better wood; "huachapelí," however, is most highly esteemed, and it is said that canoes of this wood have a life of a hundred years or more. One of these canoes was nearly 15 yards in length, but the ordinary length is from 6 to 9 meters. The canoe is usually strengthened with timbers and given greater freeboard by the addition of a pine plank on each side. They may be fitted with a large squarish sail called a "vela cuadrada" or a "banda."

Boats of good modern types are to be found at almost every port. When the first foreign fishermen (Italian and Spanish) came over, Mediterranean

[a] *Malacochæte totora* is used for boats, sails, pontoons, weirs, thatching, etc.

[b] On the brief trip to Mollendo the writer did not have opportunity to examine a balsa made of the hides of sea lions, the description of which must, therefore, be omitted.

types of boats were introduced, and it is said that for some time the ready-built boats were imported by ships coming around the Cape. However that may have been, the boats are all built in Peru now and chiefly of American white pine strengthened with oak. A variety of types are in use, of which the neatest is the felucca ("faluca" or "falucho") as it is employed at Callao. This has a round bottom and smooth sides, is pointed at both ends, and may be entirely decked. There is a long, narrow hatch, the "escotilla," and in the extreme aft end a small "escotilla de popa" opening into a compartment in the stern dignified by the name of "salon" and used for the storage of nets or fish. With the covers of the escotillas in place, the little boat is snugly decked in. The space under the forward deck serves for bedding, clothing, and other things, while under the side decks are spaces ("escafetas") for the keeping of cooking utensils, provisions, and miscellaneous equipment. Though the boats are small, yet for the period of a fishing trip the fisherman regards his boat as his home and equips it accordingly. A typical Callao felucca is 5½ meters in length, 2 meters in width, and 0.65 meter in depth.

As typical of the felucca, the mast stands about midway and supports a triangular lateen sail; that is, a triangular sail which is attached by its fore margin to a lateen yard or "entena." The entena hoists obliquely to the mast. For use in the scallop dredging, greater power and convenience are secured by modifying the sailing rig. The mast is then placed well forward and a boom and gaff sail (schooner-like) is used.

These closely decked feluccas are found only at Callao. In other ports the boats are usually square of stern and uncovered. At all ports the boats seem to have no other name than "bote de pescadores" (fishermen's boat), the designation by which they are distinguished from the bote chalanos, canoas, balsas, and caballitos.

One of the common inferior boats of the coast is the bote chalano, with square stern, steep sides, and flat bottom, or, as at Callao, with a wedged but fore-and-aft planked bottom. At Callao it is used with a large square sail.

All of the boats are without centerboards and are comparatively poor sailers into the wind. Therefore if a fishing trip is made to northward of the port, the return journey against both wind and current is always tedious. The use of the centerboard is unknown.

The best sailing craft are the "balandritas" or small sloops of Pacasmayo. The balandras used there for trips to the Lobos Islands are 25 to 30 feet in length, with a 7 to 10 foot beam and a depth of 3½ to 6 feet. Square of stern, well decked in, and with a small cabin, they have fair seagoing qualities and may carry from 10 to 14 tons. The balandritas are of the same form, but smaller.

They are good sailers and are well adapted for trolling in the bay for the 40-pound robalos.[a]

Reference to boats would not be complete without mention of the American whaleboats which from time to time have been left by the whalers in the region of Tumbes. They are used in the local whale fishery and for other purposes. Valuing economy of nervous energy more than saving of time, the fishermen of Tumbes avoid any trouble from the centerboard, and cripple their boats, by securely sealing the centerboard well from below.

METHODS OF FISHING.

Besides a few small and unimportant hand nets, such as the "chaya" and the "bajia," there are only four or five types of nets in use. These are the "ataraya," or casting net; the "red derecha," or gill net; the "chinchorro," or beach hauling seine; the "anchobetera," and the "trasmalla."

The "trasmalla" (trammel-net) or "red de tres paños" (net of three cloths) is clearly an innovation, and is now found only where it has been directly introduced by the European fishermen, as at Callao and Mollendo. The others are doubtless indigenous to the country, although in some cases apparently modified by modern influences.

Where there are good beaches the fishermen wade into the surf to throw the ataraya, but, except when the valued lizas are abundant, the method is slow and profitless. (Fig. 4, pl. XIII.) The gill net, "red," or "red derecha," is essentially the same wherever found, though appearing under a variety of names, according to the size of the mesh and the kind of fish for which it is intended. Used at the surface or at the bottom, set straight or traplike, in the form of the letter S or of a figure 6, employed in the far off shore fishery for bonitos or in the treacherous surf on a steep shingle beach, it may have a mesh of any size from 1½ to 10 centimeters. Thus we find it as a "pejereyera" (1½ to 2 cm., bar measure), "cabinsera" (3 cm.), "lizera" (4 to 5 cm.), "bonitera" (5 to 7 cm.), "corbinera" (6½ to 9 cm.), "robalera" or "cazonera" (9 to 10 cm.), according as the net is designed for the capture of fishes of the sizes of peje-reys, cabinsas, lizas, robalos, cazones (large sharks), etc. The measures are always stated in "dedos" (fingers), one dedo being equivalent to about 2 centimeters, diagonal measure, and therefore the measure in dedos corresponds approximately to the bar measure in centimeters. The greatest part of the catch of the entire coast is taken by these nets.

The chinchorro is used where there are suitable beaches. It is a hauling seine, with a bag or bolsa about 7 fathoms deep by 2½ high. In the back or

[a] Chalanos, feluccas, and balandritas may be valued, approximately, at 200 soles, 400 soles, and 600 soles, or at $100, $200, and $300, respectively.

bottom portion for 2 fathoms it is of small mesh and strongly reenforced, while the outer portion is of larger mesh (about 8 centimeters). The long "brazos" (arms), or "bandas," extending out from each side of the mouth are 13 fathoms in length and 50 meshes (10 cm. each) in height. In making a haul, two canoas or balsas are used in putting the net, while it is drawn onto the beach by several men, often with two or three mules.

Perhaps the most characteristic net is the anchobetera, a modification of the chinchorro, used in taking the little anchobetas, which occur in such vast schools. The bolsa, or copa, is 4 or 5 meters in depth, and, when flattened, 9 or 10 meters wide (that is, 18 to 20 meters in circumference). The opening or mouth of the bolsa is surrounded by a sort of funnel, of four portions; the upper and lower "pechos" (breasts) with a mesh of 9-centimeter bar, and the right and left "sobacos" (armpits) with a mesh of 20-centimeter bar. From the sobacos the brazos, or arms, lead out on each side with a length of 5 or 6 fathoms, and a mesh of 40-centimeter bar (16 inches). In surrounding small schools of anchobetas, the net is worked from canoas or balsas. A larger net of the same type may be used for "sardinas," as referred to on page 342. It would be called a "sardinera" or a "red clara."[a]

In the way of line fishing, we find the simple still-fishing line, or "cordel," the trolling line, or "cordel bonitero," and the trawl-line or bait-line—the "espinel."

The espinel is of particular interest, as one of the most effective methods of fishing and as being the only method by which one of the very best fishes of the coast is taken in any abundance. As used at Callao, Chimbote, etc., the espinel carries 50 to 100 hooks on short lines attached at intervals of 1 to 2 meters, and it is worked in 20 to 30 fathoms of water. The espinel fishery, however, is best seen at Mollendo. Fishing in 46 fathoms at a trial on the usual fishing grounds, and using a line of 1,500 hooks, our fishermen took 256 congrios at one haul. As the hooks were attached (by 30-centimeter side lines) at intervals of 1 meter, the length of line fished was nearly 1 mile, but such a line is readily worked by one man with an assistant to control the boat. The line was set after 7 o'clock in the evening and taken up after midnight. The catch of about 400 pounds of the best fish, made at one haul of the line, was considered good, but not unusual, and the fishermen describe hauls of 700 pounds on 1,200 hooks kept in the water for four or five hours.

[a] The name "clara," it may be remarked here, is at first confusing, being applied to nets of very different types. The "clara" is the clear net—that is, the net which the smaller fish can pass through. Therefore, fishermen who speak of the anchobetera as "la red" (the net) would call the same form of net with larger mesh the "clara;" in another community, where the gill net for cabinsas was the net in most common use, and therefore spoken of as "la red," the "clara" would be a net of somewhat larger mesh, such as the "lizera" or the "bonitero." Thus in one community the "red clara" is a gill net, while in another community it is an entirely different type of net.

In this case only four fishes other than the congrios were taken (two sea basses and two rays), and it is significant that the congrio appears not to be taken in any numbers except by the use of the espinel. The congrio, eaten fresh, is considered an unsurpassed food fish, and, as will appear on a later page, it gives the best salt product prepared in Peru. It seems surprising, therefore, that the espinel is not more extensively used. The method is relatively laborious, but the yield is in proportion to the labor. Undoubtedly, the reluctance of the fishermen to use it is due, not so much to the amount of work involved, as to its relative intricacy, the necessity of much preparatory work in the securing of bait, the baiting of the many hooks, the arrangement of the lines in the tubs, and, finally, the constant care required in the manipulation of the line in order to avoid mischievous tangles.

At Callao the espinel is not often used, and then only in a small way, the fishermen preferring those methods which, however much actual labor they may involve, require the least forethought. The congrio is practically unknown to the market there. Even at Mollendo, where the effectiveness of the method is not infrequently demonstrated, it is not regularly used, the fishermen choosing rather to throw a shot of dynamite near the rocks and scoop the fish from the surface. Undoubtedly there are extensive fishing grounds which will become available only with the extension of the espinel fishery or by the introduction of the bottom trawl-net ("red barradera").

Dynamite must be mentioned as one of the common methods of fishing. This abuse is certainly working an incalculable damage, especially in certain regions. It is prohibited by the government, but the efforts to prevent its use have so far been ineffectual, and the practice is at present the most serious defect of the fishery.[a]

PRESERVATION OF FISHERY PRODUCTS.

Some of the methods of preservation employed are of especial interest, but before particular mention is made of these, a word may be said as to the significance of the fish-preservation industry to the country.

[a] A list of apparatus used for taking sea fish in Peru would be made nearly complete by adding the following to those that have been mentioned above: The dredge, or "rastra," employed in the scallop fishery, especially at Callao, and a rather better rastra formerly used in the abortive pearl fishery at Sechura and Paita; the net for turtles, or "tortugera;" the gig, or "fisga," for taking the flounders at Callao, a little oil being sometimes poured on the water to make the surface smooth; the "bolador," made of wood in the form of the dasher of an old-fashioned churn, which is thrust sharply into the water, making a loud sound to drive the fish into the gill net or the trammel net; the pole and hook ("gancho"), for taking gobies and devilfishes from the rocks; the lance ("harpón"), thrown at the larger fish from the shore, from a pier, or from the boat; the harpoons, as rarely used in the fishery of swordfishes ("peje-espada") at Mollendo; and the ordinary harpoon and hand-lance outfit employed in the shore fishery of whales at Tumbes. We are not here concerned with the various baskets and hand nets with which the fresh-water shrimps are taken, or with the methods employed in the lake and river fisheries of the interior.

For want of convenient methods of transportation, it is only the people of the ports who can have the luxury of fresh fish, and even these may know it only as an occasional delicacy if the fishermen are accustomed to work at a considerable distance from the port. To the people of the interior only salt fish is ever available, and they prize it highly. Even this is a rare luxury in most parts of the country, however, on account of the rather unsatisfactory preservation of fish and the entire want of system in the marketing and distribution of the product. At some ports, in fact, neither fresh nor salt fish are regularly obtainable.[a]

At the island groups of Guañape, Lobos de Afuera, and Lobos de Tierra practically all the fish taken are preserved by salting or drying for the supply of the region of coast between Salaverry and Paita. Paita even boasts a small exportation of salt fish, since two balandritas convey annually about 50,000 fish ("sierras," "bonitoes," "caballas," "peje-blancos," and "meros") to Manta, in Ecuador, and other ports of the north.[b]

That preserved fish is not more available to the people of Peru is rather remarkable in view of the general occurrence of deposits of salt. In almost every part of the coast are found salt beds of greater or less purity. In some places, as near Pisco, cakes of almost pure salt can be picked up from the ground. The extraction, refining, and sale of salt are restricted, however, to the National Salt Company, and the common market price is exceedingly high. So far as I am aware, only the fishermen of one village, San Andres, near Pisco, have the privilege, especially granted them, of taking for themselves the comparatively good salt from the hillsides near the shores of Paracas, where they commonly fish for peje-reyes and other fishes. On the other hand, the Government, realizing the absolute necessity of cheap salt to the fishermen, has made special arrangements for their benefit. Each fisherman is entitled to receive monthly from the salt company 2 quintals (200 pounds) of salt at a nominal price, while for such further quantities as he may need the price is fixed very much below the regular market price. These arrangements would seem to be most satisfactory to the fishermen, at least; but the indigenous fisherman has an almost unconquerable prejudice against the purchase of salt, and will rarely go beyond the allowance, although often complaining of its inadequacy. In times of especial abundance, quantities of fish are therefore sold at small prices or allowed to spoil.

One of the expedients of the fishermen, resulting only in part from the inadequacy of the salt supply, is the use of what they call "salitre." The

[a] The importation of salt and canned fish in 1905 amounted to about £38,361 ($186,800), but the imported product does not reach a large proportion of the natives, who are without fish food of any kind.

[b] Sierra, *Scomberomorus sierra;* bonito, *Sarda chilensis;* caballa (mackerel), *Scomber japonicus;* peje-blanco, *Caulolatilus* sp.; mero, not identified.

word means saltpeter, but it is applied by them to what is merely a natural mixture of salt and sand and other impurities, which may be found near some of the villages. It is claimed by many of the Indian fishermen that the fish preserved with the so-called salitre will keep in better condition for eating than those preserved with pure salt.

The crude native methods of drying anchobetas have already been noted. Occasionally these little fishes are prepared in small quantities, by pickling, so as to make a very palatable food.

Generally speaking, no choice is exercised in the selection of fish for preservation; any fish that comes to hand and is regarded as edible will be packed away. There are certain forms of preservation, however, which seem to be worthy of further description.

Preservation methods at Mollendo.—The fisheries of Mollendo, though not extensive, would form a chapter in themselves. The markets of the port and of Arequipa, the second city of the country, display a variety of fish products not seen in the more northern markets.

On some accounts the most interesting fishery product of this region is the peculiar dry and tangled egg-mass which is found on the local markets as "cau-cau." This is the egg-mass of the "volador" or flying fish, which is collected in season and dried that it may be kept on the markets throughout the year. These eggs have an especial interest from the fact that, although flying-fish eggs have been known to science for nearly fifty years, they were, until quite recently, attributed erroneously to the little sargasso fish (*Pterophryne*) of supposed nest-building habits. A few years ago, after the discovery of the true eggs of *Pterophryne*, the identity of the eggs of the so-called "nests" with those of the flying fishes was soon established. The cau-cau appears to have been a product long familiar to the natives of this part of Peru, by whom the eggs have been attributed, and correctly as it seems, to the flying fishes.

Each egg is 2 millimeters in diameter, and its membrane is produced into a number of filaments, which, though rather scattered over the surface of the egg, have a tendency to a bipolar distribution. The filaments, though very fine, are quite long and the fibers of different eggs are thoroughly intertangled, to unite the many eggs into a closely woven mat. Sometimes the filaments are so twisted together as to give the appearance of a well-defined thread.

The cau-cau of the market, then, is a large number of the shrunken berries, entangled to form a shapeless mat. A mat may be a good double handful or more, and the filaments are so completely interwoven as to make it difficult to tear the mass into portions. When soaked in water the eggs will expand and take an appearance as if freshly laid. They are found in early summer, beginning with October, and are said often to be entangled with weed. My visit was in July (midwinter) and the cau-cau then on the market was quite free from

seaweed. Floating seaweed is, indeed, not common in the region, and the mat form of the large and otherwise shapeless masses suggests that they were formed while floating at the surface.

The most important preserved product of the region is the "charquecito," made from the congrio, a reference to the capture of which fish has already been made. The preparation was not observed, but as it was described the congrios are opened, cleaned, washed in salt water, and hung up to dry. Six or eight days later they are thrown into piles ready for the market. The drying and subsequent preservation must be watched with care to prevent heating or curling. The tail bends up in drying and must be pressed or bent out to preserve the desired appearance. The charquecito is the most highly esteemed preserved fish, but, like all fish products of the coast, it is rarely shipped to other ports. It brings a good price, 5 or 6 reals per pound (25 to 30 cents American).

Besides the charquecito and the cau-cau, a number of minor products are preserved. Dried seaweed is prepared by the simple process of putting the fresh weed into molds and pressing it into flat plates, which, after being dried in the sun, are folded and are then ready for sale. The seaweed used is called "uyos" or "cocho-uyos," but the species so dried is not the ordinary "cocho-uyos" that is eaten at other ports.

"Lapas" (fissurellids) and "barquillos" (chitons),[a] after being boiled and stripped of the shell, are dried and strung, and a "sarta" of two dozen of these "atados" (strings) is sold for the very small sum of 30 centavos, or about one-third the price of the fresh shellfish.

The "pincho de mar," a holothurian, is skinned and dried to make a crude trepang. "Ocoti," or "pota," is the sea anemone[b] stewed and stripped of the skin. It is sometimes dried. It is a custom for the Serranos, or inhabitants of the interior, coming down to the coast at Ilo, to take back with them the trepang, ocoti, etc., along with the cau-cau and charquecito.

In this connection it may be mentioned that, besides the characteristic methods of preservation practiced in this region, other fisheries are followed here that are rarely found in other ports. The capture of the swordfish ("peje-espada") is sometimes attempted, and at least one fisherman is well equipped with the necessary harpoons. The swordfishes are said to weigh 200 to 400 pounds and to bring 26 to 50 soles each ($13 to $25).

The prized "erizos" (porcupines), or sea urchins, are more commonly taken here than elsewhere. Ascidians, which bear the surprising name of "ciruelas" (cherries), are stripped of the test, so that the inner portion is taken out "como

[a] Lapas, *Fissurella costata* Lesson, *F. crassa* Lamarck; barquillos, *Chiton granosus* Trembly; *Enoplochiton niger* Barnes.

[b] *Phymacter clematis* (Dana) Milne-Edwards, as identified for the U. S. National Museum by Prof. J. Playfair McMurrich.

un huevo" (like an egg) and is eaten raw or in soups under the name of "cochizo" or "piuri."

Finally an allusion should be made to the taking of the abundant bogas, suchis, and peje-reyes (species of fresh-water fish) in Lake Titicaca. These fishes are considered delicacies and are brought down to Arequipa, the chief city of the region. Dried lake peje-reyes were observed on the market.

At Lobos de Tierra.—Reference has been made to the capture of selachians and flounders in the region of Lobos de Tierra. Many of these are preserved by sun drying and without the use of salt or other preservative. The process is of some interest, as the fishermen are peculiarly expert in preparing the fish.

On the return from the fishing trip, after the fish are thrown into piles on the beach, the first matter is the apportionment of the catch, since two or more fishermen have worked together. The division accomplished, they set to work individually to prepare the fishes for drying. Each man has beside him, when at work on the beach, an oar or a board sprinkled with sand and used for sharpening the knife. A short sharp sheath-knife is used and it is whetted by a stroke or two on the oar after almost every cut that is made. The "guitarra" (guitar-fish) is laid on the sand with the back up. Five cuts practically prepare the fish. The first splits the right and left sides incompletely apart, leaving the backbone in the left half; the second lays open the right side of the head; the third lays open the right side of the body; the fourth lays open the left side of the body; the fifth lays open the left side of the head. A few quick slashes to better expose the meat for salting, the removal of the entrails, and the making of a slit in the tail by which to hang the fish complete the process, and the fish is thrown aside for washing.

The "angelota" (angel-fish) must be cut a little differently, but the process is accomplished with hardly less dispatch. The outer parts of the outer fins are first removed. The first cut splits the fish; the second lays open the right side with the aid of a few additional slashes in the meat; the third and fourth lay open the left side. The head, gills, and entrails are then cut entirely away and the body of the fish is thrown aside to be washed.

The small boys assist by taking the opened fish, two at a time, into the water and washing them free of the sand, blood, and other dirt. The fish are then hung from poles by the slit in the tail. Two or three slender pieces of cane put crosswise keep the skin stretched, and the fish are thus left to dry in the sun. Four days is said to be sufficient for the curing if the weather is bright. Hanging in this way, they look like merely a series of skins, but the meat is all present as a thin layer on the skin. No salt or salitre whatever is used on them. They are strictly sun cured, as flat thin sheets of skin and meat.

"Tollos" (small sharks) and "cazones" (large sharks) are prepared in very much the same way as the angelotas.

The "rayas" (rays) are handled in an interesting way. The fish is laid on the back and two circular cuts are made. The first cuts away the lower wall of the mouth and gill cavity, leaving this wall hanging as a flap on the left side anteriorly; the second cuts away the lower wall of the abdominal cavity, leaving this as a flap on the left side posteriorly; the entrails are then removed; a vertical cut from above is made through the backbone from the head to the base of the tail and one or two short cuts may be made on each side of the thick base of the tail; a series of cuts are then made across the disk of the raya, which now looks like a circular gridiron. These crosscuts extend to the skin below.

When all the rayas are prepared, sand is rubbed well into the cuts of each, and the fish is laid in a hole in the ground. The hole is covered with boards or mats or by filling with sand, and the fish are thus left in the sand on the beach for a day to let the moist sand absorb the blood. They are then taken out, washed and salted, after which they are laid across poles or logs to dry in the sun. Three or four days are required for the drying.

With regard to the use of salt, the fishermen state that salt is never used on guitarras, but is always used on rayas; angelotas and tollos are prepared with or without the use of salt, according to preference or to the quantity of salt available. Salitre is used to some extent, but salt is considered much better.

The waste products in the preparation of the fishes are simply thrown on the beach and the "gaviotas," or gulls, gather in great numbers to eat them. The eggs of the guitarra are supposed to have a certain medicinal value, and are sometimes saved for this purpose.

On the mainland the dried fish bring from 10 to 60 centavos apiece, according to the demand. Practically all of the ordinary fish taken here are salted, but at the time of my visit few fish, other than the selachians mentioned and flounders and mackerel, were being taken.

Oils.—In the illustration (fig. 7, pl. XV), there is seen, below the drying fish, a turtle shell, into which has been thrown a quantity of turtle fat. Placed, as it is, in the sun, the shell is tilted so that the oil flows out into a can placed below the point of the shell, which serves as a spout. The oil is used medicinally, especially for dressing wounds of man or domestic animals, and also to take internally for troubles of the liver. Turtles were seen abundantly in this region. On one occasion I saw 10 heads of turtles thrust out of the water to breathe at one moment and within the space of a few yards. They were feeding on the abundant seaweed of these shores. In this part of Peru, however, the turtles are rarely used, as the meat is not valued. The only place where a turtle fishery was observed was in the south, at Pisco. The meat is there sold locally at 25

to 30 cents the quarter or less, but the real object of the fishery is the oil, which is valued for miners' lamps.

A net for turtles, or "tortugera," at Pisco may be about 80 fathoms long by 2 fathoms or a little more in depth. A net observed had a mesh of 30 centimeters (1 foot) bar. In the use of this net the fishermen, working near the shores, watch carefully, and when a turtle is seen, put the net out as quickly as possible. One to 5 or 6 may be taken at a time, or, when they are especially abundant, as many as 10 may be taken at one haul. Two fishermen, working together, may take as many as 80 turtles per week. January, February, and March are regarded as the best months in which to take them, because they are fattest in those months.[a] The fat is thrown into a big pot of 8 to 10 gallons capacity and slowly cooked, while the shells are used for fuel. The fishermen state that 80 or 90 turtles yield 16 to 20 tins of oil, selling at 3 soles (about $1.50). Computing from these figures, the oil yielded by an individual turtle would be worth from 27 to 38 cents, while the total catch of two fishermen in one week might be worth $24 to $30 for oil, besides the value of the meat.

The fishery for whales off the coast of Peru has been pursued by foreign vessels for more than a hundred years. After an English vessel, manned by American whalemen, made a most successful voyage around Cape Horn in 1788–1790, the coasts of Chile and Peru soon became favored whaling grounds for both English and American vessels. The agreeableness of the climate off the coast of Peru, the freedom from dangerous storms, the convenience of certain ports, the abundance of whales, all conspired to make it a favored cruising ground, and Callao, Paita, and Tumbes became places of common resort for refitting and provisioning. Peru derived a direct commercial benefit from this fishery. Tumbes gained more than this; for sometimes the crews were recruited with local sailors, and occasionally these native recruits, acquiring experience and skill, rose to the rank of officials of the boat crews. In this way the "Tumbeseños" learned the methods of the whale fishery, and the way was opened for a national fishery. For at least twenty years persons or companies of Tumbes have followed this fishery, employing the well-equipped whaleboats left behind by the foreign whalers. It is, however, a small fishery, 10 to 14 whales in a season being accounted a good catch. The season of 1907 was a very poor one, only 4 whales being captured, with a yield of about 6,500 gallons of oil, valued in Tumbes at about $1,300.

The coast has long been abandoned by all foreign whalers except a few Chilean boats, which are supposed to take about 150,000 gallons of oil each year. At the local valuation this would amount to approximately $30,000. The

[a] Turtles are not known to come on the beaches to lay in this region, nor so far as I know, south of the region of Tumbes, where it is said that the nests are made about September. The only common turtle of the coast is the Pacific green turtle. The tortoise-shell turtle is said to be found very rarely.

Chilean boats, which are said to use the whaling gun and explosive harpoon, probably take chiefly the sperm whales; while the native whalers confine their attention to the humpback whales found nearer the shore in the Gulf of Guayaquil, and employ only the harpoon and lance thrown by hand. The Gulf of Guayaquil is reputed to be a favored breeding ground of the humpback whale, and it is about at the bearing season (May, June, etc.) that the local fishery is pursued.

Except the preparation of oil from turtles at Pisco and the capture of whales at Tumbes, there is no fishery for oils in Peru.

For a time the sea lions ("lobos de mar") were taken for the oil and hides, but the government prohibited the continuance of the fishery, partly because of the use of dynamite and partly that an inquiry might first be made as to the relation of the sea lions to the guano-producing birds. It was a question whether the lobos were injurious to the birds, in the competition for food, or were of real assistance to them in so herding and demoralizing the surface fishes as to make them more available to the birds. It is probable now that the fishery will be resumed under proper regulations and restrictions.

The porpoises and dolphins seem never to have been sought; in fact, many of the fishermen have a peculiarly friendly feeling for these animals, believing that in some way they aid the Christians ("ayuda los Cristianos").

Fur seals, "lobos finos" or "lobos de dos pelos" (lobos of two coats), while undoubtedly occurring on the coast as far north as Paracas, are not abundant enough, nor perhaps of sufficient value, to support a fishery. The "gato de mar" (sea-cat), a species of river otter (*Lutra*) that lives in the sea, is not uncommon in some regions, but is never abundant. Its pelt when taken is regarded as of some value.[a]

FUTURE OF THE FISHERY INDUSTRY.

In spite of the antiquity of the fisheries of Peru, and notwithstanding the introduction of European fishermen with their improved boats and nets, the industry is now so inadequate and unsatisfactory that the larger part of the people of Peru are not supplied with a class of food which they peculiarly appreciate.

Some of the difficulties are inherent in the situation in a country whose industrial life in all its phases is relatively undeveloped, and many of these difficulties will disappear naturally as the country generally advances further in the path of industrial progress which it has so propitiously entered. Rapid and frequent transportation between ports is wanting, railroad rates are neces-

[a] We are not concerned with the preservation of the large fresh-water fishes by smoking and other methods which are practiced on the headwaters of the Amazon. I have been informed that this is such an extensive industry that smoked fish in that part of Peru is a more common food than beef.

sarily high, and ice is at present at almost prohibitive prices. The fishery industry everywhere is without that organization and specialization which marks the higher stage of development attained in many other countries. Each fisherman makes his own nets, conveys his catch to port, sells the fish fresh or preserves them by salting or drying for sale at a future time—everything in an individual way. Experience in other countries shows that economy is the result of systematization, and that the middleman, even if characterized as the "necessary evil," may not only keep the market more regularly supplied but also give the fisherman a better average profit and the consumer a lower average price. So in Peru we find the fish when unusually abundant thrown away or sold at a very low price, because the fisherman has not the means or lacks the energy to preserve a large catch, while the public complain of an irregular market and of an excessively high price in ordinary times. I have referred to the unusual appreciation of fish-food by Peruvians. Rarely is a meal served without fish where it is obtainable, yet to a large part of the people beyond the ports this much-prized luxury is seldom to be had.

Modernizing the fishery is not sought for itself, for many of the original Peruvian methods of capture are suited to the natural conditions and best adapted to the social nature, the abilities, and the wants of the people. Except in Callao and Mollendo, the fishermen are all native Peruvians but slightly touched by the wave of modern progress. In attempting to introduce new and larger methods, it would be unnecessary and unjust to hamper or antagonize a kindly people, poor in wealth but rich in contentment, who are working out a peaceful and honorable life after the bent of their nature. The caballito and the balsa, the chinchorro and the anchobetera, the camerone traps and other native nets may long continue to give satisfactory food to many Peruvians. Yet if the native fishermen may be taught to capture their fish more abundantly, and to salt and dry them more efficiently, their labors may be the more profitable and the more useful to them and to others. Furthermore, without prejudice to them, their fisheries may be supplemented by those who can pursue the industry in a larger way and with better organization; and this is clearly necessary if the larger part of the population of Peru is to obtain fish and to have it regularly and cheaply.

The abundant catches of the excellent congrios made with the espinel (trawl line or bait line) in the region of Mollendo and the success of this method when used in other parts show well that, although relatively laborious, it could be more extensively employed to great advantage. The deep bottom trawlnets, while not actually tested in Peruvian waters, would in strong probability prove successful, and it is much to be desired that experiments be made with them. The use of power boats will be necessary, and the introduction of these for quick conveyance of fish to market will enable the fishermen to

spend a greater proportion of their time upon the fishing places, increase the territory conveniently accessible for the markets of Callao and Lima, and open new fishing grounds. Finally, the opportunities are excellent for the proper preservation of several kinds of fish by various methods.

II. THE GUANO INDUSTRY.

The guano problem, which is perhaps the most important economic question confronting the nation of Peru to-day, has been included in the fishery studies partly because it is impossible entirely to dissociate the guano industry and the fisheries in protective and regulative measures. Strictly, indeed, we may consider guano a fishery product, for it is formed by the birds from the small fishes, which swim in such enormous schools along this coast. Chiefly for this reason, in fact, I have on a previous page referred to the anchobeta as the most important resource of the waters of Peru. It is, however, an inadequate statement of the relation of the guano and fishery industries to say that the existence of the guano-producing birds in Peru is dependent upon the presence of large schools of fish. One of the most important products of the fishery industry of the United States is the fish guano made by direct manufacture from the menhaden. In Peru a nearly equal value of guano is produced annually from the anchobetas through the agency of the birds. This guano is obtained far more cheaply than if the process of manufacture were depended upon, since it can be brought from the islands at little more than the cost of transportation. (Fig. 8, pl. xv.) It is a very significant practical question to what extent Peru should continue to depend upon the birds for the production of nitrogenous guano, or whether the direct manufacture of fertilizer from the fishes should be undertaken in order to supplement the present available supply. This question will not be specifically discussed at this time, but the matter here presented has a very direct relation to its solution.

Peru owes the importance of its guano deposits, not only to the abundance of the sea birds and the fishes upon which they feed, but in equal part to those natural conditions which have permitted the conservation of the nitrogenous parts of the guano. Had the coast been subject to rains, or were the climate more moist, the nitrogenous portion of the guano would have been converted into ammonia and lost by evaporation or drainage. There would have resulted then, at the best, a phosphatic guano of relatively low value. The guano consists, as is well known, of the excrement of birds and sea lions, with the other offal matter of the rookeries, consisting of bodies of birds and sea lions, birds' eggs, and fish. For our purposes the sea lions may be excluded from consideration. Undoubtedly they have lent considerable bulk to certain deposits of guano, but, from such information as can be gained, it seems practically sure

that apparent deposits of seal guano which have given a high analysis owe their chemical value in large measure to bird guano which has been formed with it.

THE PROBLEM.

It is difficult to overestimate the significance of the guano problem to Peru. It is not merely that the country is threatened with the loss of an exportation industry which has yielded important revenues; the sugar and cotton planters of the country have been coming more and more to recognize the value of the fertilizer for the production of their crops. In fact, with the relatively crude methods and the inefficient labor, combined with the necessary expense of irrigation, the profit from these crops is, to a considerable extent, dependent upon the availability of a cheap fertilizer. Even at this time the nation's agriculturists are estimated to require 40,000 tons annually, while, under existing conditions, they have been able to secure only about two-thirds of this amount. The guano deposits have been so mortgaged for the payment of the bonded debt that, under the present arrangements, the largest part of the guano must be exported. Thus, in 1907, of approximately 124,000 tons of guano extracted, only 26,000 tons were taken for the agriculture of Peru. Under a continuance of the present conditions, it is certain that even this proportion of the nation's requirement can not be obtained for more than a few years longer.

The exhaustion of the old deposits will soon be realized. It is true that there have been "false alarms" in the past in this regard. Islands which have been proclaimed exhausted have been revisited and have afforded new supplies of the fertilizer. This has been due only in a relatively small degree to the continued deposition of the birds; in part it is explained by the occasional discovery of new deposits of buried guano; but that the same island has been successively exhausted two or more times is chiefly accounted for by the fact that the term "exhaustion" has been used in a relative sense. At one time it was not profitable to extract guano lower than a certain grade, while at a later time the market would be content with a fertilizer of much lower nitrogen value. It would become profitable, then, to return to "exhausted" islands where the lower grades had remained.

At present the old guano supplies are reduced to the very lowest grades that it would be profitable to extract and transport to foreign markets, and the approximate amount of such guano being known, it is estimated that at the present rate of exportation all the available guano of old formation will be removed within four or five years. It is not probable that new deposits will be found of sufficient quantity to change the present outlook materially.

It is clear, therefore, that within a few years the guano industry will be dependent upon the yearly production of the birds. The amount of this new production can not be stated accurately, but it is fairly estimated to be between 20,000 and 30,000 tons. This amount, if divided as now between the export and the home trade, would be of comparatively little value to either. The estimated annual production is, indeed, less in number of tons than is actually required by Peru's agricultural industries alone; but since the new guano has a much higher average nitrogen value than the guano that is now used, and on which the estimated annual demand is based, it is probable that the yearly formation would meet the present demands of home agriculture. Furthermore, it is believed that with the adoption of the correct method of working the islands, and with the most thorough protection of the birds, there would result a material increase in the production of guano, sufficient to keep pace for a considerable time with the growing demand. It is even possible that there would be a surplus for exportation.

THE GUANO-PRODUCING BIRDS.

At least twenty-four species of birds frequent the islands, not including seven species observed at sea in proximity to the islands and coast. Twelve of these were observed nesting on the islands. From the commercial standpoint the chief birds are the cormorant, the pelican, and the gannet, the first and last mentioned being the most abundant birds on the coast.

THE CORMORANT.

The white-breast cormorant (*Phalacrocorax bougainvillei* Lesson), the paramount guano-producing bird, occurs along practically the entire coast, nesting on the level ground or the more gentle slopes, and always in closely crowded rookeries (fig. 9 and 10, pl. XVI). This cormorant, the "guanay," occurs most abundantly in the south, at the Ballestas and Chincha islands. The nests are closely crowded over great areas, where it may readily be ascertained that they average about three to the square meter. At the close of the season there may be allowed at least four birds to a nest, counting the parents and one pair of young. The population of a flock, after the young are raised, may therefore be estimated by multiplying by twelve the number of square meters covered by the rookery. On the Ballestas and Chincha islands in June, 1907, rookeries of 4,600, 10,000 to 12,000, and 60,000 square meters, respectively, were measured, and other smaller rookeries were observed. These flocks, then, must have contained 55,000, 120,000, and 720,000 birds, respectively. At a later time the last-mentioned flock, on the South Chincha Island, was so much increased, chiefly through recruits from the other flocks, that a million birds could have been only an underestimate of its population. The photograph (fig. 9, pl. XVI) shows but a very small portion of this immense aggregation of birds.

It may be of interest here to consider for a moment the potential commercial value of such flocks of birds. Let us assume that each of these birds leaves upon the island daily a single ounce of guano. This is actually an underestimate, as such a rate of deposition would not account for the quantity of guano actually extracted after a year's accumulation on a rookery; but on this assumption of 1 ounce a day for each bird, the deposit would grow daily by 1,000,000 ounces, 62,500 pounds, or 28 long tons. A million birds would then produce over 10,000 long tons of guano per year. Such an amount is probably not actually formed at this ground, for the reason that a million birds is a decided overestimate of the average number of birds on the rookery throughout the year. However, on the assumption of 1 ounce of guano per day per bird, it follows that 100 birds would produce 1 long ton of guano per year.

We may come more nearly to the actual conditions. From the various calculations I have made it appears that a rookery will yield about 1 long ton of guano per year for 28 nests. This guano of the "guanayes" is very high in nitrogen, giving an analysis of 12 to 14 per cent and higher, and we may value it at $40 per ton.[a] Twenty-eight nests, or 28 pairs of birds, have an annual producing value of $40. We give a fair idea of the commercial significance of these birds to Peru when we say that each brace of birds contributes annually $1.43 worth of guano, besides leaving a pair of offspring to continue its service. Is it not, then, of the greatest importance that the fullest protection should be extended the birds, and every possible precaution taken to insure that there may be the maximum number of birds at every rookery, and that these birds may remain upon the rookery the maximum amount of time?

Previous to making the above computation, from observations at other rookeries, I had estimated the number of nests on the south island of the Chinchas at 180,000, and, by an independent series of measurements of the deposits of guano at various places in the rookery after two years of accumulation, had estimated the amount of guano at between 12,000 and 15,000 tons. Making a new calculation on the basis of the figures just worked out—that is, 1 ton to 28 nests—the 180,000 nests would give 6,400 tons per year, which is in close agreement with the original computation from measures and weights taken on the rookery.

[a] The cost of guano to a Peruvian farmer can not be taken as a basis of valuation, since the government practically gives the guano to him, exacting a tax of only 1 sol (about 49 cents) the ton. The expense to the farmer is merely the cost of extraction and transportation. The cost of a ton of 9 per cent guano on the farm is, therefore, only $12 or $13 in American gold. This cost, however, does not at all represent the value of the guano, if the cost were based on the ordinary laws of supply and demand. The real value to the farmer can not be computed.

The guano for export was consigned to the exporting company many years ago by a process of adjustment, in return for the acceptance of certain obligations; so that it is not practicable, either, to calculate the value of the export guano on the ground.

However, considering the high selling value of guano of such excellent quality in foreign markets, and since the cost of extraction is less than $5, and the freight relatively low, it can not be considered unreasonable to assume that guano of this high anaylsis has a value to the world of $40 per ton.

THE PELICAN.

The second bird in importance is the "alcatraz," or pelican (*Pelecanus thagus* Molina), although it has not now nearly the rank of the cormorant. The pelican is not only far less abundant, but it appears that its guano is distinctly less in quantity and inferior in value to that of the cormorant. It can not be said in what degree this is due to an inherent difference in the birds, or to the fact that the cormorant breeds chiefly on the islands of the south, where the conditions are better for the preservation of the guano, while the pelican now breeds chiefly in the north where the atmosphere is more humid, and therefore deleterious in its effects on the deposits of guano.

There is one thing of especial importance for consideration in regard to this bird. The pelican, of all the useful birds, is the one which seems to be most affected by the disturbances incident to the extraction of guano, and therefore, of the three chief commercial birds, it is the one which has been most reduced in numbers. This may offer a reasonable basis of hope for the future. It does not appear that the breeding territory of the pelican was always confined as now to the northern regions. The islands of the south are smaller, so that the working of the islands is more directly disturbing to the birds. It is natural, therefore, that the rookeries of pelicans in this region should now be small and confined to the outlying and less accessible rocks. In the north, on the other hand, the islands of Lobos de Tierra and Lobos de Afuera are comparatively large, giving more opportunity to the birds to separate themselves from the guano workers. During recent years, too, the extraction in the north has usually been restricted to one group of islands, while the other was left to the undisturbed possession of the breeding birds. It is unfortunate that during the past two years both islands have been worked, with results which can not but be seriously injurious to the welfare of the pelicans.

In March, 1907, large pelican rookeries, with eggs and all stages of young, were observed to the eastward of the Lobos de Afuera islands and an islet just off the north end of this island. During the following winter, about August probably, the birds were entirely routed from these islands, and the rookeries were swept clean of guano. A new home was established on the westward island, where the photograph (fig. 11, pl. XVII) was taken in December, in the early part of the laying season. Not a single bird remained to make its nest on the islet, and only a few very small and scattered rookeries were found on the entire eastward island.

In March, 1907, there were probably about 80,000 flying birds (mature and immature pelicans, not counting the nestlings of every stage) using the Lobos de Afuera islands at night. In December, 1907, there were between 20,000 and 40,000 nesting birds on the same islands. The irregular nature of the rookeries

made it impossible to arrive at a more definite estimate. Probably by the following March, after the rearing of a brood of young, this number was nearly doubled, but it can hardly be supposed there were so many as in the preceding March.

It is believed that a proper consideration of the welfare of the pelican would promise much benefit to the country. It may be expected that with the most careful protection, the bird would increase materially in numbers in the north, and even more so in the south, so that in time the pelican would have a much higher value and would take a rank nearer to that of the cormorant.

THE GANNET.

The common "piquero," a species of gannet (*Sula variegata* Tschudi), which von Tschudi considered the most important bird (and this view seems to have been generally accepted), is still important, though of far less value than the other two species mentioned. However, on account of its habit of nesting on the cliffs and other comparatively inaccessible places, the great proportion of the guano is now lost in the sea, and it is doubtful whether the bird has ever had a commercial value comparable to the cormorant or the pelican. (Fig. 10, pl. XVI.) With the better systematization of the guano industry in future years, much of this guano now lost might be saved by the construction of shelves or other collectors at the bases of the cliffs.

Von Tschudi found that a single piquero in captivity would produce 3½ to 5 ounces of guano per day. If each bird leaves about its nest 2 ounces of guano daily, 1,000,000 piqueros would leave 20,000 tons per year. The piquero is so abundant and so generally distributed along the coast that 1,000,000 would seem a low estimate of the number of birds on even a portion of the coast. The piquero breeds throughout the year and the nests therefore are always in use.

THE PENGUIN AND THE PETREL.

Only two other species require particular mention. The penguin, or "pajaroniño" (*Spheniscus humboldti* Meyen), is now of almost negligible value, but was formerly so abundant as to be highly ranked by Raimondi. The rookeries are confined to the caverns, and the guano is considered very good, although there is little of it.

The "potoyunco," a species of petrel (*Halodroma garnoti* Lesson) of oceanic habit except for its nesting in subterranean homes, is still significant, but in relatively low degree. The nesting places are found on many islands, however, especially on the lofty San Gallan. Great areas of the surface of the ground, from the lower hillsides to the tops of the peaks that are usually capped with clouds, are undermined by nesting chambers of these birds. They will burrow indifferently through the hard crust of sand on the hillsides or beneath the

cloud-fed vegetation of the hilltops. The guano produced here must be of significant quantity, and it is reputed to be of high quality. It is remarkable to note that this little bird was given first rank by Raimondi.

The penguin and the potoyunco from their habits are the most helpless against ruthless destruction, and they seem undoubtedly to have been reduced from a condition when they possessed a much greater economic value than now. The exterminating process still continues, as both birds are frequently killed by the fishermen and the guano laborers. The potoyuncos especially are regularly sought by the fishermen. They can easily be captured at night in their underground nests, and quantities of them are taken to be salted and sold on the mainland. If adequate protection is extended to these two birds it seems reasonable to hope that they would increase in numbers toward the former condition of abundance and again take rank as important economic assets.

It is not within our province at present to speak of the other cormorants, another gannet, the gulls and terns, and the shore birds which are found on the island and coast. None of these species, individually, has a commercial importance, yet it must be remarked that, collectively, they may add materially to the total quantity of guano which may be swept from the ground.

EXTRACTION OF GUANO AND PROTECTION OF THE BIRDS.

Under the existing arrangement, all of the guano that is exported from the country is taken by a single corporation, which has offices in Lima, as well as in London, New York, and other cities. The corporation does not usually work the islands, but has the guano extracted by contract, paying to the contractor so much per ton delivered to the vessel. Often these contracts, involving only a few thousand tons, are given to native contractors. A large part of the export guano, however, is extracted by a single commercial company, which works now upon the northern islands. From this guano the government derives no present revenue, but the amount extracted is reported to the government and credited against the amount of guano which has been mortgaged to the corporation for obligations of the government previously taken over by the corporation.

The guano for the Peruvian agriculturists is extracted by a similar contract system, with the following method of procedure: The farmer who desires guano applies to one of the many individual contractors. A typical contract may be instanced. The contractor agrees to sell and the farmer to buy 600 metric tons of guano at 14 soles (about $7) the ton, the guano to give an analysis of 9 per cent of nitrogen. The contract further provides that if the average analysis is higher or lower the farmer will pay an additional price of 1 sol per ton for each unit of nitrogen above 9, while 2 soles the ton will be deducted from the

price for each unit below 9. Another type of contract might cover a larger quantity of guano, say 5,000 tons, to be delivered during four years, certain stated amounts to be made available each year. The contractor, having calculated the amount of guano necessary to fulfill his contracts for a given year, applies to the Ministerio de Hacienda (corresponding to our Department of the Treasury) for a concession to take such and such amounts of guano from stated islands, and, if the concession be awarded, the contractor pays to the government 1 sol for each ton conceded. In case of failure to obtain the amount asked for, and on which payment has been made, the government adjusts the matter equitably by continuing the balance of the concession to the following season or refunding the proportionate part of the payment.

This introduces one of the weakest points in the present method of extraction. It frequently happens that two or three or more concessionists are authorized to take guano from the same island. Only one who has lived on the islands while the working was in progress can appreciate the bitterness of competition that ensues. The disputes, the threats, and the personal violence which may arise are aside from the question. It is the effect upon the birds that is of vital moment.

Since it is understood that a concessionist establishes finally his claim to any deposit of guano by throwing this into piles, and since the best of the guano is found at the rookeries, disaster to the birds is inevitable. The first party to arrive, or the strongest, as the case may be, obtains possession of the rookery, and within a few days the entire breeding ground is torn up and the birds completely routed, without regard to the presence of immature birds or unhatched eggs. Under a better system a responsible contractor would at least allow the birds to use a portion of the ground, while, with as much consideration of them as possible, the guano was being extracted from the remainder. I should not omit to add that I have seen some concessionists working in this intelligent way where there was due opportunity. (Fig. 8, pl. xv.)

The government has not failed to recognize the necessity for protection of the birds. The destruction of birds or of eggs has been made a penal offense, and it is now practically stopped. It is a difficult matter to keep a thorough surveillance of a long coast, where the towns are widely removed, and of many islands, some of which are miles from the mainland. Hence there is still some violation of these laws, and the potoyunco, as has been mentioned, suffers especially from such depredation. At times, too, the eggs of more important birds may be taken, but the wholesale robbery of nests has been practically eliminated. Formerly the eggs were valued for food and for use of the albumen in clarifying wines, and it is said that enormous quantities were taken regularly.

That which most concerns the present government is how to regulate the working of the islands so that the necessary amount of guano may be taken

with as little detriment as possible to the birds. Two years ago a "closed" season of five months was established, to include the months of November to March, which constitute the height of the breeding season, and the writer was instructed to make a study of the habits of the birds, with reference to determining whether such a period was proper or adequate, or whether other methods of regulation were required. As a result of the studies made on various visits to the chief rookeries, it became apparent that the closed season adopted was inadequate, although it was a most significant step in the right direction and has undoubtedly already yielded results of value.

The pelican rookeries on the 1st of April were covered with eggs containing live embryos, and with all stages of young birds, immature and incompletely feathered. Young pelicans only partially feathered were to be found as late as June. Cormorants were feeding their young from mouth to mouth in June, while already the preliminary love plays and preparation of nests for the following season were in progress. By the end of July a large number of eggs were laid for the following season and a few even had hatched.

It follows, therefore, incontrovertibly, that there can be no season when the islands may be worked without disturbance of the birds. I believe the rookeries of pelicans and cormorants are never deserted voluntarily except for so long a period in the day as may be necessary to secure food. The breeding season of the gannet, as has been mentioned, is continuous throughout the year.

It becomes very clear, then, that only a very carefully and consistently followed plan of rotation in the working of the islands would insure the birds the best conditions for undisturbed breeding. For a period of at least five years certain islands in each region might be left as the unmolested abode of the birds, while the extraction of guano was being prosecuted on other islands. At the expiration of that period, certain other islands would be closed while the accumulations of guano on the previously closed islands would be available for extraction. The system might be worked out in such a way that each year certain islands would be opened, and a steady supply of guano be available each year.[a]

In partial adoption of a plan of rotation, the government has kept the south island of the Chinchas entirely closed during the past two open seasons, and it is estimated that by the expiration of the third year of closure there will have accumulated on this one island about 20,000 tons of guano of the highest grade. It is only fair to state that the government has enforced the closed season and kept this island closed in the midst of very serious difficul-

[a] The plan which the writer drafted in 1907 for the Chincha and Ballestas Islands and other points of the region (Boletín del Ministerio de Fomento, Junio, 1907) may be cited as an illustration. After further observation of the birds on the rookeries, I would modify this plan by using five-year instead of three-year periods, as was then suggested.

ties. We have seen that it has proved impossible to grant to the farmers of the country the full amount of the guano which they desire. However warmly and sincerely the principle of regulation may be indorsed, there must be faced a strong and not unreasonable cry from the many farmers for more fertilizer. Only by the opening of the middle, and later of the north, island of the Chinchas, which it had been intended to keep closed, and by the opening of the Lobos de Afuera Island, was it possible to give to the farmers the two-thirds portion of the guano which they required.

A large and important industry with exacting relations to creditors and to national agriculture can not be thrown upon a new basis in a moment; but the interests of all concerned are linked with the welfare of the industry, and it is believed that those on all sides who have power or influence are giving serious attention to the matter. It is probable that the proper solution of the question will not long be delayed, and we may confidently anticipate a brighter and far more satisfactory future for the guano industry, at least so far as the people of Peru are concerned.

CONCLUSION.

As a concluding word, it may be stated that the investigation of the fishery and guano industries was taken up a little less than two years ago. The first step has been the collation of data regarding the industries, the methods in use, and especially the conditions and the opportunities for development. The studies of the present writer conclude at this point. It is intended by the government to continue these studies and to adopt practical measures that will facilitate the development of the industries. It is evident that important economic results may be gained which will benefit both the fishing population and the country at large.

It is hoped also that arrangements may be made to investigate the fresh waters of the interior with reference to determining whether it is possible and profitable to introduce new species of fish into some of the lakes and rivers.

It is to be added that the government appreciates the ultimate necessity for an accurate knowledge of the marine fauna and flora, and desires to promote a knowledge of the natural history of the country. With this in view, the writer was instructed to collect the chief economic forms and others associated with these. The collections thus made will probably not include many new forms, except of the fishes, but it is intended that they shall serve as a basis for systematic reports illustrating the economic forms and epitomizing the present systematic information regarding the more important economic groups. To this end the collections will be intrusted to specialists in the various groups. It is believed that the reports will be of value to science and that they will be of especial service to those who may in future have the opportuinty to enlarge our knowledge of the natural history of a comparatively neglected region.

Fig. 1.—A characteristic scene on the coast desert, taken from the Southern Railroad between Arequipa and Juliaca.

Fig. 2.—Mouth of the River Rimac near Callao. On the left the ocean, on the right the lagoon formed by the river. The water of the lagoon escapes into the ocean by seeping through the natural dike of shingle

Fig. 3.—Gathering oysters from the mangrove trees, Tumbes.

Fig. 4.—Native fisherman in the surf, throwing the ataraya (cast net).

Fig. 5.—A Peruvian fishing with hook and line from a caballito, Pacasmayo.

Fig. 6.—Balsa on Lake Titicaca. Made of reeds.

Fig. 7.—Drying sharks, guitar-fishes, etc., without the use of salt. Lobos de Tierra.

Fig. 8.—Sacking guano to be shipped by anda-rivel (automatic trolley). Ballestas Islands

Fig. 9.—A very small portion of a flock of cormorants on the south island of the Chinchas.

Fig. 10.—A small flock of cormorants on the top of the south island of the Ballestas. Gannets are barely distinguishable on the ledges.

Fig. 11.—Pelicans on their nests, Lobos de Afuera.

THE FISHERIES OF CHINA

By Wei-Ching W. Yen

Second Secretary Imperial Chinese Legation, Washington, D. C.

Address before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

THE FISHERIES OF CHINA.

By WEI-CHING W. YEN,
Second Secretary Imperial Chinese Legation, Washington, D. C.

Mr. PRESIDENT, FELLOW-DELEGATES TO THE FOURTH INTERNATIONAL FISHERY CONGRESS: My colleagues and I deem it a great honor to participate in the proceedings of this assembly, and our only regret is that owing to unexpected circumstances two others were prevented from leaving Shanghai, thus reducing by one-third the strength of our delegation. Doctor Smith, the distinguished and learned secretary-general of this congress, has very courteously requested us to address you in a general way on the fisheries of our Empire—for various reasons so little known to the outside world. While it is true our principal object in attending this congress has been to avail ourselves of the opportunity of obtaining information from the distinguished assembly present on all questions pertaining to fisheries, it is also our object to inform the world of the efforts being made in our country to investigate the conditions of our fishing industry, to collect statistics, to study its needs and defects, to introduce new types of vessels and fishing apparatus and methods, and to initiate legislation and regulation—in short, to organize and develop the industry and to place the culture and propagation of fishes on a scientific basis.

The history of fisheries in our country, like that of many other things, is an old one. Our ancient classics refer to the times when our primitive ancestors tied ropes together to form fishing nets, and mention the appointment, several centuries before the Christian era, of special officials to rule over and protect our fishermen. The first statesman that recognized the importance of the fishing industry was Chiang Tzŭ-ya, who lived in the eleventh and twelfth centuries B. C., and who rose to eminence from an humble home on the coast. It is said that this wise and virtuous angler, then 80 years of age, was fishing with a straight piece of iron, upon which the fishes readily allowed themselves to be caught, when the Emperor Wên Wang discovered him, and for twenty years he served his imperial master faithfully and successfully. Through his ardent efforts and wise planning, fishing first became an important industry among our people, and with it also grew up its allied industry, the manufacture of salt, without which the former would have been seriously crippled for want of preservative facilities.

Our most ancient pisciculturist was Tao Chu Kung, who lived in the fifth century B. C. His method of fish culture combined both knowledge and ignorance. He dug a pond of the size of an acre, leaving nine small islands scattered about. In the pond he placed 20 female carps 3 feet in length and 4 male ones of similar size. This was done in the month of March. In March of the following year there were found 5,000 fishes one foot long, 10,000 two feet long, and 15,000 three feet long. In the third year the number had been multiplied ten or twenty times, while in the fourth year it was not possible to keep count. The nine islands were to deceive the fishes, who would believe that they were in the big ocean traveling around the nine continents.

Pisciculture in our country has been confined to fresh water kinds. The fry are fed with the yolk of eggs, with very fine bran, or with beans ground to a powder. When the fish reach the length of a foot or so, they are transferred to a pond, where they are fed with young grass. It is considered advisable not to have the ponds too deep for fear of the water getting too cold for the young fish, and certain plants and trees are grown around and over the pond for various purposes and with various objects. For instance, it is believed that the dew from the plaintain leaves has a medicinal effect on the fishes, the berries of a certain tree are relished by the young fishes as a food, the grape vines which cover the pond prevent birds from polluting the water, and the luxuriant growth of the hibiscus along the edges repels the invasion of beavers. Of course, all these beliefs and theories are not scientific, but are based on tradition and experience.

With the division of the people of the Empire into four distinct classes—scholars, agriculturists, artisans, and merchants—the men and women who followed the trade of fishing for a livelihood were placed in an anomalous position, in that they were not included in any of the four classes. Thus socially ostracised to a certain extent, they clung more and more to themselves, forming groups and colonies of their own along the coasts and on isolated and rocky islands. They lived in a world of their own, knowing nothing of the affairs of their country and caring less. To this day they do not come into direct contact with their countrymen on the mainland or in the interior, disposing of their catches of fish to fishmongers, who go out to them during the fishing season with silver or with the necessaries of life in exchange for the fishes.

Throughout our history the importance of the fishing industry has been dwarfed by its allied industry, the manufacture of salt, which, having been transformed into a government monopoly, has engrossed the attention of the official and merchant classes.

In discussing the fisheries of our country attention must be called to the difference in taste between our people and those of the West. In the first place, our epicures do not care much for deep-sea fishes, and a fish like the salmon would not at all appeal to our palates. We delight in eating those of the finny

tribes whose meat is soft and fine, and they are to be caught in rivers, brooks, lakes, ponds, and the surface of the ocean. Another factor which has checked the development of deep-sea fishing has been the lack of rapid transportation facilities and of refrigerative means, necessitating the preservation of deep-sea fishes in salt before they could be sent inland. On the other hand, there are products of the sea which are regarded by us as delicacies of the table, but which have little or no consumption in the West. Just to mention a few well-known ones, the fins of the shark, the bêche-de-mer, the cuttlefish, the jellyfish, the scallop, and the awabe form important articles of domestic commerce, but are not bought or sold to any extent in the West. Many people of the West poke fun at us for what may be termed our motley taste for fish food. They declare that we are omnivorous, as far as eating the products of the sea is concerned. It seems to us that if the standard of civilization is partly to be measured by the ability and ingenuity of the people to maintain life by utilizing the variety of foods placed at its disposal, then we have helped to solve one of the important problems of life. We have found so many of the finny tribes suitable for food and capable of being transformed into delicious dishes that it is possible for us to have a fresh species on our table every day during the year.

The more common of the edible fishes in our country are the perch, mackerel, sturgeon, goby, pomfret, eel, gudgeon, shad, sole, mullet, flounder, herring, carp, bream, etc.

With our dense population it is a matter of necessity that we seek our food from the waters as well as from the air and the land. As a writer has said, "All waters are vexed with our fisheries. Our nets and other contrivances for capturing fish display great ingenuity, and most of them are admirably adapted for the purpose (and no wonder, with our centuries of experience and experimentation). The right to fish in running streams and natural waters is open to all, with a few exceptional cases, while artificial reservoirs, as ponds, pools, tanks, tubs, etc., are brought into available use; rice fields near tide water are turned into fish ponds in winter. As to the modes of securing the inhabitants of the deep, they are killed with the spear, caught with the hook, scraped up by the dredge, ensnared by traps, and captured by nets; they are decoyed to jump into boats by painted boards, lifted by lifting nets, and dived for by birds—for the cormorant seizes what his owner could not reach." The last-named method is unique, I believe, in the world, and in our country is confined to one family, the Liu family. The fishes caught, however, are limited to those of creeks and small streams and of unpalatable kinds, bought and eaten only by very poor people.

With the spread and growth of new ideas through intercourse with western nations, the possibilities of the fishing industry have become more and more apparent to our leaders, and it is realized that for a proper development the whole industry must be thoroughly organized and all modern improvements in

the way of vessels, apparatus, and methods of fishing, aquiculture, etc., must be introduced. A bureau of fisheries, modeled much after the pattern of the West, with headquarters in Shanghai and branches in Mukden, Tientsin, Chefoo, Canton, and Foochow, has been established. The maritime provinces of Fêngtien, Shantung, Chêkiang, Kiangsu, Fukien, and Kuangtung have interested themselves in the work of this bureau. Investigation has been made of the different types of vessels, nets, and other apparatus employed in the industry, of the groups of fishermen and their methods of fishing, of the habits and rules and traditional usages obtaining among fishermen, with a view to governmental legislation and regulation, and also of the numerous islands and rocky coasts, which have for centuries been the resorts of our fishermen. The last-mentioned work has been carried out with the cooperation of instructors from our naval college at Nanking. This fisheries bureau, more commonly known as the Kiang-Chè Fishery Company, is authorized and recognized by our Ministry of Agriculture, Works, and Commerce, and has for commissioner-general the taotai of Shanghai.

Established only about four years ago, the fisheries bureau is of course only in an embryo state, but in a general way much has been accomplished. The industry has been encouraged and developed in that protection has been afforded to the fishermen from attacks of pirates, from clandestine fishing by foreign vessels in Chinese waters, and from illegal exactions by official underlings. By the construction of houses for the storing of natural ice, the sale of fresh fish has greatly increased. A fishing vessel propelled by steam power was purchased, but so far the vessel has proved to be a failure from the financial point, for the simple reason that deep-sea fishes can not fetch good prices in our country. Two years ago the bureau succeeded in sending a very complete exhibit of the fisheries of our Empire to the Milan Exposition, and those of you who were present will remember the numerous models of fishing boats and fishing nets and the hundreds of finny creatures caught in Chinese waters that were placed on view. We have with us this time models of 19 different kinds of fishing nets, which you may examine at your leisure.

It is proposed to establish a large fishery school at Woosung, the entrance to the city of Shanghai and the resort of numerous fishing boats, the funds being contributed by the governments of 11 provinces. The site has already been chosen and leveled, and construction of the building will begin in the immediate future. As a nucleus of this future college—for it is hoped the institution will grow into a college—we have already organized a school, with 100 pupils, mostly sons of fishermen. Connected with the school is a museum, and it is planned to construct an aquarium on a large scale.

One of the more important duties of the bureau has been the collection of statistics, a branch of knowledge much neglected by us in the past. The work is full of difficulties, but from a cursory examination it is found that the total

number of salt-water fishing vessels is in round numbers 200,000, one-fifth of which hover on the coast of Chêkiang Province.

The canning and preserving in other ways of fish after new and improved methods is growing gradually into importance. In Canton, in particular, it is becoming a valuable industry.

Such in brief is the state of the fisheries of our country. The activities of the bureau, you will notice, have been confined to the practical rather than the scientific side. There is a great deal more to be done, but at present its usefulness has been circumscribed by the lack of funds and of competent men. So many new measures are being introduced that necessarily the energies and resources of the Empire have been very much divided.

In attending this congress my colleagues and I have had it impressed on us to gather as much information as possible, to visit the various centers of fish culture, and to meet the leading scientists and experts engaged in the work, from whom we expect much assistance and with whom we hope to work together in the future.

THE FISHERIES OF JAPAN CONSIDERED FROM A GEOGRAPHICAL STANDPOINT

By T. Kitahara, Ph. D.
Imperial Fisheries Bureau of Japan

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

THE FISHERIES OF JAPAN CONSIDERED FROM A GEOGRAPHICAL STANDPOINT.

By T. KITAHARA, Ph. D.,
Imperial Fisheries Bureau of Japan.

It is a well-known fact that the Japanese are among the most extensively fish-eating people of the world. The average annual consumption of fish in Japan, to my estimation, is nearly 50 pounds per head, a high average not surpassed by other nations, except the Norwegians and the Canadians. Although the preference for fish as an article of food is said to have originated from some religious belief in the old time, now the people of Japan are in the position of being forced to take it as the most important diet, because they have very small pasture for raising cattle, while there are seas to fish near at hand all around the country.

The Empire of Japan, as you know, stands off the northeast coast of Asia, stretching from southwest to northeast for nearly 3,000 miles, and from the tropical to nearly the frigid zone, washed by the warm as well as the cold currents. Thus it can be seen that Japan, so far as the maritime conditions are concerned, is much like the Eastern States of North America. The Gulf Stream may be compared with the Japan Current, the Labrador Current with the Kurile Current, the Gulf of St. Lawrence, probably, with the Japan Sea. The fishes which inhabit the waters of Japan are also like those of America to some extent, as regards both character and distribution.

But unfortunately we lack such great fishing banks as the Grand Banks off Newfoundland, the Georges Bank off Cape Cod, etc. On the contrary, Japan has the deep abysses along the east coast which are useless for the fishing industry, but give rise to the terrible earthquakes and awful tidal waves that at times destroy lives and property along the shore. This condition seriously affects the development of the fisheries in that part of the country. In fact, the Japanese islands, being as a whole steeply built, have but few submarine plateaus. The area within the 100-fathom line, i. e., the continental shelf, is only about 77,000 square miles, while that of the Chinese and the Korean seas comprises nearly 200,000 square miles, and that of North America about 1,000,000 square miles.

It naturally follows, therefore, that the fishermen cling to the shore for the bank fishing, and consequently their boats are very small and not ocean-rigged, being mostly shorter than 30 feet. Such small boats now number 400,000, and they are very densely distributed on the comparatively narrow shore fishing grounds, which are so actively fished over that the important shore fishes have been greatly decreased. I believe the shore fisheries of Japan are in the climax of development, and there seems to be very little room for further increase. The only hope for future progress rests upon the growth of the pelagic fisheries on the deep high seas.

Understanding these conditions in regard to the fisheries of Japan, we come to consider:

1. How to repopulate the depleted shore fishing grounds.
2. How to encourage the pelagic fisheries in general.

The first question is very difficult to solve, and when solved is not easy to practice, and we can not as yet report any good results, except in the artificial propagation of the salmon, on which I shall touch later. As to the second question, to make effective encouragement an act was passed by the Imperial Diet in 1897 by which fishing steamers of more than 50 tons and sailing vessels of more than 30 tons may receive certain subsidies from the Government. Since this act has been in force several vessels have equipped for the pelagic fisheries, but unfortunately the greater number of these vessels were for pelagic sealing, which is regarded with such disfavor by the American and Russian authorities. In my country, too, the increase of sealing vessels is not encouraged. Indeed, the profit from the fur seals is very limited, and it is not a wise policy to promote an industry which causes so much international difficulty.

The amendment to the act and the by-laws in 1905 were with the view that all important pelagic fisheries may receive subsidies. The lower limit of tonnage of sailing vessels was therefore reduced to 20 tons. Moreover, in case of vessels newly built under the instructed plan, they also may have a certain support from the Government. These amendments proved effective, and many fishing vessels were equipped for pelagic fisheries other than sealing. Among other vessels the *Fuji Maru*, of 25 tons, with an auxiliary gasoline motor, made a great catch in bonito fishing in 1906, which resounded throughout all the fishing communities, awakening the fishermen from a long sleep in the old methods of fishing. I believe Japan will have a great revolution in her fishing vessels within a few years, and will as a consequence increase the supply of the pelagic food fish.

It is a significant fact that the whale fishery on the high seas has sprung up with fullest vigor since 1905, almost regardless of the government encouragement. There are now 28 whaling steamers, while there were only 2 schooners in 1904. This wonderful development of whaling is, I think, partly because of the prohibition of whaling in the Norwegian seas and partly because of the

abundance of whales in the seas of Japan. Most of the gunners employed are from Norway.

Before closing I want to call your attention to some of the methods of fishing and fish culture introduced from America. The most important of these is the purse seine. It was first introduced into Japan by Mr. K. Sekigawa thirty years ago. After a good deal of encouragement, it was applied to the catching of sardines and herring; and now hundreds of such seines are being used on the southeast coast. It is not yet used for mackerel fishing, as in America. The artificial propagation of salmon and trout, which was introduced by the same man, is no less interesting; and Japan owes much to the kindness of the American authorities. There are now some 20 hatcheries in northern Japan, which annually yield about 35,000,000 fry. The fishermen are now in firm conviction that the beneficial results of artificial propagation of the salmon are beyond doubt. In fact, they have established by themselves several hatcheries at their fishing grounds. The rainbow trout, which was first introduced thirty years ago and new lots of which have been brought over several times since then, is thriving well in the lakes at Nikko and Aizu.

I have great pleasure in expressing thanks in behalf of my country for the ever kind aid that the American authorities have given for the promotion of Japanese fisheries and fish culture.

GOLDFISH AND THEIR CULTURE IN JAPAN

By Shinnosuke Matsubara

Director of the Imperial Fisheries Institute, Tokyo

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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GOLDFISH AND THEIR CULTURE IN JAPAN.

By SHINNOSUKE MATSUBARA,

Director of the Imperial Fisheries Institute, Tokyo.

JAPANESE VARIETIES OF GOLDFISH.[a]

That the goldfish of Japan was originally introduced from China there is no doubt, but a long domestication of the fish has resulted in producing several Japanese varieties. The four known from remote times are as follows:

"*Wakin*" (Japanese goldfish).—This variety bears a close resemblance to the original *Carassius auratus* from which it came. Its body is slender and long, and the black pigment gives it when very young a color like that of steel, which gradually changes into vermilion red, often variegated with white. The caudal fin is either simply forked or split into three or four lobes. (Pl. XVIII.)

"*Ryukin*" (Loochoo goldfish).—This variety has a short rounded body with a protuberant or swelled-out abdomen. The caudal fin, pendulous when at rest and flowing when in motion, is as long as the body or sometimes still longer, all the other fins being also long. (Pl. XIX.)

"*Ranchu*," otherwise called "*Maruko*" (round fish).—The body of this variety is short and rounded, its tail and broad head being also short. It has no dorsal fin. The head, which is free from any abnormal features when the fish is quite young, in two or three years develops all over it a number of protuberances, like the achenia of a strawberry. In this state it is called "shishigashira (lion-headed) ranchu." Owing to the fact that this variety has a globular body, a short protuberant abdomen, and a short caudal fin, it can hardly swim, and is usually seen in an erect position with the head downward, which may be accounted for by the absence of the dorsal fin. (Pl. XX.)

"*Oranda shishigashira*" (rare lion-headed).—This resembles the ranchu in its bodily form with strawberry-like protuberances on the head. The body is big and longer than that of the ryukin and furnished with the dorsal fin; the caudal fin is long. (Pl. XXI.)

Among the older varieties are also the following:

"*Demekin*" (goldfish with protruding eyes) *and* "*deme ranchu*" (ranchu

[a] The ten colored plates accompanying this paper have been made from water-color drawings from life by J. Urata, and have been copyrighted by the author.

with protruding eyes). The former was first introduced from China toward the close of the Japan-China war (1894–95). It has protruding eyeballs, and the body and the caudal fin are short. It is not usually bright colored, being black all over the body or yellowish red variegated with black spots or irregular patches. The deme ranchu, first brought from China six or seven years ago, has a globular body and, like the ranchu, no dorsal fin. The eyes not only protrude, but also are turned upward 90 degrees. (Pl. XXII and XXIII.)

The foregoing are varieties for some time cultivated in Japan or recently introduced from China. New varieties, however, different from these, have lately come into existence, and I shall now describe how and in what order these have been produced.

TYPICAL FORMS OF GOLDFISH TAILS.

1. Arrow tail, lateral view.
2. Tassel tail, lateral view.
3. Forked tail, lateral view.
4. Three-lobed tail, dorsal view.
5. Bag tail, lateral view.
6. Rudder tail, lateral view.
7. Four-lobed tail, dorsal view.

"*Watonai.*"—When the Fisheries Exhibition was held in Tokyo in 1883, I saw there exhibited a highly interesting variety of goldfish, which was a wakin with a flowing caudal fin. Being struck with its extreme peculiarities, and inquiring how this variety came to be produced, I found that the exhibitor, who lived at Imaidani, Akasaka, Tokyo, had only one pond for breeding goldfish, and that there the said variety was produced. As in that pond all the different varieties just stated above were reared together, the strange new variety appeared to be a cross between the ryukin and the wakin; but I did not make at that time further investigation into the cause. That breed was called "watonai," which means "a variety hitherto found neither in Japan nor in China." (Pl. XXIV.)

As to the order in which the different varieties of goldfish have been produced in Japan, it is probable that the wakin stands first in priority, but in what order the others have come can not be definitely stated. The oranda shishigashira, however, is generally known to have been produced by crossing the ryukin with the ranchu at Koriyama, Yamato, in 1840. All the new varieties of recent times except the watonai, which comes first in order, were produced by Mr. Akiyama Kichigoro, a goldfish breeder in Tokyo. The latest produced varieties are the following three:

"*Shukin.*"—In 1897 a new variety, having its own peculiarities, was produced by the following means: Oranda shishigashira, ten in number and 3 years old, were crossed with ranchu equal in number and also of the same age. The cross thus made produced about 300 young fish, of which some were like the oranda shishigashira in form. There were 20 entirely without the dorsal fin; but in a large majority of the young there were some traces of the dorsal fin, one to three spines or something like knobs being discernible in its place. Those without any dorsal fin were then selected for breeding purposes, and in their offspring were still found some with traces of dorsal fin such as the spines and knobs mentioned above. This variety without the dorsal fin has been kept breeding up to the present; and being requested by the breeder to give it an appropriate name, I called it "shukin" (literally "autumn brocade"). The adjective "shu" takes its rise in the breeder's name, Akiyama (Chinese, Shu-zan, i. e., "autumn hill"), and the "kin" signifies "brocade," the epithet being given on account of the beautiful bright color. (Pl. xxv.)

"*Shubunkin.*"—The year 1900 first saw this new variety. The goldfish hitherto known in Japan having no such dapples as are found in the Chinese demekin, which is dappled in three or four colors, the breeder had wished to have a variety produced having the same dapples as the Chinese. Thus the males and females, each ten in number, of the demekin having the most attractive dapples were crossed with an equal number of the males and females of the wakin. The breeding fish selected were the demekin having black dapples on a vermilion red or purple ground and those speckled with red, white, black, and blue. Some of the offspring resembled the original *Carassius auratus* in form and had dapples like the demekin, while in some others the scales were not so conspicuous as is the case with the demekin. On the whole, however, those resembling the wakin were most numerous, while those similar to the demekin in form were very few; and the number of the cross the breeder had in view was only 100 out of a total of 500. This new variety, to which I gave the name of "shubunkin" ("vermilion red dappled with different hues"), has since been kept breeding. Among its descendants some were of a vermilion color, dappled with black, some of a purple color all over the body

without any dapples, and the others speckled with three or four colors. The entirely purple color above referred to was quite an unknown thing in the parent fish. (Pl. XXVI.)

"*Kinranshi.*"—With a view to obtaining a new variety without the dorsal fin, the ryukin was crossed with the ranchu. The number of parent fish, as well as the numerical ratio of the males to the females, was the same as in the preceding case. The offspring thus produced were of a bright attractive color. Some were provided with the dorsal fin or spines, others partially provided with the former, while in some others there were protuberances in place of the dorsal fin. Those entirely destitute of any dorsal fin numbered only one-third of the whole. This last-mentioned variety, which I called "kinranshi" (brocade-figures), has been kept breeding up to date. (Pl. XXVII.)

Of these three new varieties, the shukin is the most popular, but the shubunkin the most profitable one, only a few of the latter being eliminated on account of the caudal fin being crooked or irregular.

The goldfish is cultivated almost all over the Empire, but most extensively in Tokyo and Koriyama, Yamato, Nara Prefecture. Broadly speaking, the most popular varieties are those cultivated in these two localities, and the methods of rearing goldfish most in vogue are also those followed there. The northeastern half of the Empire follows Tokyo in things relative to the goldfish breeding, while Koriyama leads the southwestern half.

GOLDFISH CULTURE IN TOKYO.

The varieties of goldfish cultivated in Tokyo are the ranchu, the ryukin, the demekin, and the wakin. Attempt was once made in Tokyo to cultivate the oranda shishigashira by introducing the fish from Koriyama. This variety was not regarded with much favor, however, and has come to be scarcely ever cultivated in the capital. The most popular breed is the ranchu, which is highly prized by goldfish lovers and engrosses a great deal of the attention of breeders, who take pride in producing the best of this variety.

RANCHU.

This fish is chiefly cultivated in concrete ponds. When the culture is carried on upon a small scale, the usual number of parent fish is five, two of which are females and the others males, but when it is carried on upon a large scale, the number of parent fish is over fifty, one half of these being male and the other half female. The eggs are laid during the period between the beginning of April and the middle of May, and the utmost attention should be paid to the fish during the three months of September, October, and November of the preceding year, when the food should be given them in sufficient

quantity, without their being overfed. The males of the parent fish are separated from the spawners some time before the latter deposit their eggs. When the spawning season approaches, the water of the pond is not renewed, but the fish are kept amply fed with the larvæ of mosquitoes (*Culex pipiens*) or earthworms (*Limnodrilus* or *Tubifex*) for about ten days, at the end of which time the eggs are laid when the temperature of water in the pond rises or when it rains. As, by experience, this can be known beforehand, the water of the spawning pond is changed the day before and the parent fish are removed thither. The spawning bed is then made with "kingyomo" (*Myriophyllum verticellatum*), on which the eggs are deposited on the following morning.

When the number of parent fish is 5, the proper size of the pond is 4 by 3 shaku (1.2 meters by 91.0 centimeters) with a depth of 5 sun (15 centimeters). With 50 parent fish, the area of the pond should be 7 by 6 shaku (2.1 by 1.80 meters), the depth remaining the same as before. In a pond of the latter size, a circular concavity with a diameter of 8 sun (24 centimeters) to 1 shaku (30 centimeters) and with a depth of 1 sun 5 bu (4.5 centimeters) from the bottom of the pond, is made around the outlet for the water. This concavity is intended to prevent the fish from being driven, when the water is drained off, against the walls of the pond. When the spawning is over, either the parent fish or the eggs are removed to another pond to prevent the eggs from being devoured.

For a few days after the eggs are hatched, the fry do not move about, but stick to their bed or the bottom of the pond. During this time no food need be given, as every individual of the fry is provided with a yolk sac in its abdomen; if forcibly fed, their health would be impaired. In three days or so, they begin to swim about in the pond, and are then fed once every day in the morning with the yolk of hen's eggs boiled. This food is administered by straining the yolk, mixed with water in the proportion of 2 eggs to 5 sho (9.1 cubic centimeters) of water, through cotton or silk gauze, this mixture being then completely stirred up until it is yellow, when it is put into a watering pot and poured all over the pond as food. The belly of the fry becomes yellow by taking this food, and the shade of the abdominal yellowish color shows whether or not the fry have got sufficient food. After being thus fed for seven days, they are given the small crustacea, "mijinko" (*Daphnia, Moina* or *Cyclops*), which have been cultivated and kept in a separate pond, the crustacea being caught with a gauze bag and then sifted, in order that any injurious insect, etc., may not remain mixed in them. After fifteen days thus nourished with mijinko, the tender fish are fed with the larvæ of mosquitoes or earthworms cut in small pieces.

About twenty days after the fish are hatched, the first selection is made, for which purpose the fish are put into a white earthenware plate. As they are

still very small at this stage of development, it is difficult to select those which are satisfactory in every respect, and only those furnished with the better caudal fins, such as they are, are picked out. Ten days later the second selection takes place, when those having any irregularities on the back are thrown into a mud pond and put aside. Again, ten days later, the third selection is made and the fish are grouped together according to their size. And yet, about ten days after this, the fourth and last selection comes, when particular attention is paid to the form of the caudal fin. The fish are for the first time put up for sale when the third selection is over.

After the first selection the young are put into two concrete ponds, each of which is of the same size as the former one, and in the second selection they are distributed into three ponds of this same size. The area of these ponds would not be large enough for the original number of fish, but the number has been reduced as the inferior breeds were eliminated. To every twenty of the fish hatched in the beginning of May is given a space of one tsubo (3.3058 square meters), and when the cold weather comes they are removed either to a mud pond or to a hibernacle (i. e., wintering pond). The latter, which is made entirely of concrete and has a depth of 6 to 8 sun (18.2 to 24.2 centimeters), is provided with a lid, and the whole is again covered with an inclined roof opening toward the south, with one end coming down to the north edge of the pond. When the weather is warm, the lid is partially lifted up so as to admit the sun's rays into the pond from the south. The water sometimes becomes foul through the putrefaction of fish food and from other causes, in which case a basket having its lower part covered with gauze is immersed into the concavity of the pond and by means of a rubber siphon put into the basket the foul water is drawn out, to be replaced by fresh water. The fish in the second and third years should have a space of one tsubo at least for every twenty of them.

In the first year the fish attain in eight or nine months the size of 2 sun 5 bu (7.5 centimeters) from the snout to the extremity of the tail; in the second year they attain in the same length of time the size of 4 sun (14 centimeters); in the third year, 5 sun (15 centimeters); in the fourth year, 5 sun 5 bu (16.5 centimeters), and in the fifth year, 6 sun (18.2 centimeters). The fish that are kept four or five years are the only ones fetching a very high price in the market.

RYUKIN.

Being naturally very strong and healthy, the ryukin is much in demand abroad and is exported in large numbers. At home, also, this variety is a great favorite, and as such is kept in the ponds. Those having the longest caudal fin and called "ohiki," viz, "tail trailers," require at least four years for their full development. The superior kind has a head broad in front but not angu-

lar, and a short body. For instance, to be perfect in form, the body should be about 1 sun (3 centimeters) in length when it is 1 sun 5 bu (4.5 centimeters) in breadth. The body as long as broad comes next. As to the form of the caudal fin, it should be long and thin, at the same time the rays being fine and slender and the peduncle of the tail thick. To have the best coloration, it is essential that both the belly and the back should be well dappled and the tail vermilion colored. In former times when goldfish were kept in a china basin to be looked at from above only, those having the finest dapples on the back were most highly appreciated. Nowadays, however, the fish are kept in a glass tank to be viewed from the sides, hence the necessity of having fine dapples on the sides and downwards. The greatest desideratum for the ryukin is that it should have nothing abnormal in the caudal fin.

When the fish having a two-rudder tail are selected for breeding purposes, the tail becomes long in the offspring, but when the fish having a one-rudder tail are used for the same purposes, the tail becomes short in the offspring. Those having a long body and a short tail are regarded with the least favor. The second requisite for the ryukin is that the form of the body should be satisfactory, the shape of the head coming last.

A mud pond is used not only for rearing the ryukin but also for its spawning. Equal numbers of males and females of this variety are used as breeding fish, and 800 fish 3 years old are placed in a pond having an area of forty tsubo (132.2 square meters) with a depth of 2 shaku 5 sun (76 centimeters). An ample supply of food is given them in the preceding year. In order that sufficiently developed offspring may be put up for sale at the earliest possible date, the breeders vie with one another in causing the parent fish to deposit their eggs with little delay. Many of the offspring become striped like a tiger before their original steel color fades into white, and it is at this intermediate stage of their coloring that those inferior breeds destined to become white can be sold with the greatest profit. A full supply of fertilizer is required in the mud pond in which the breeding fish are kept, as it produces more plankton for them. About the end of March, when its temperature rises to 15° C., the water of the pond is renewed. In this season of the year, when the weather is very changeable, the fish require the utmost care. It is good for them if the temperature of water in the pond is higher than 15° C., but a lower temperature has a bad effect. A rising temperature accelerates the hatching of eggs, but a falling one retards it from two to three days, thereby producing a diversity of size in the offspring, an effect that should be avoided. When the eggs are deposited thereon, the bundles already referred to are removed to one or two ponds. In the case of its size being 4 tsubo (13.2 square meters), one pond may suffice to receive the eggs, but in the case of its being only 2 tsubo (6.6 square meters) the eggs are

distributed into two ponds. The more spacious the pond is, the better it is for breeding purposes.

The best food for the young is natural food, viz, plankton, which is on that account cultivated beforehand. About as much as one koku (5.2 bushels) of rice bran, soy lees or the excrement of man or horse is put into the pond, if it is 50 tsubo (165.3 square meters) in size and over 10 years old. But if the pond is only about 2 years old, a double quantity of the fertilizer is used. In each case, the pond is drained previous to putting in the fertilizer, after which its bottom is exposed to the sun's rays for about a week, and then the pond is filled with water. Another pond of 40 to 50 tsubo (132.2 or 165.3 square meters) in size is provided for receiving the fry just hatched. This pond already contains the plankton which was produced by feeding the pond with about 3 to 4 to (1.5 to 2.1 bushels) of the aforesaid fertilizer. Besides, if 1 go (0.005 bushel) of mijinko is put into the pond three days prior to removing the fry there, they increase to an immense number in that short interval.

When the young fish begin to swim about in the pond, the bundles on which the eggs were deposited are removed, and they are fed from the following morning with boiled eggs (5 in number), prepared as in the case of the ranchu. Three or four days later, when it is warm, the water in the pond is drained off by means of a rubber siphon, as stated before, and the young are put into a mud pond and fed with mijinko. Ten or fifteen days after, the fish, having outgrown the size of the pond, have to be removed to another pond. When a supply of mijinko falls short in that pond, the fish are again put into a new pond where plenty of such food can be had.

In order that the ryukin may be reared with any success, at least four ponds are required, two of which are intended for keeping the young and the other two for cultivating mijinko. In the middle of May the fish are grown so large that the larvæ of mosquitoes can be given them as food on earthenware plates slung by three strings from a bamboo pole. Given 800 parent fish, 200,000 offspring are produced, which is a proper number for the capacity (200 tsubo) of the four ponds just mentioned.

No selection of the fish is yet made at this stage of their development (the middle of May). After feeding them for about fifteen days from earthenware plates, the selection is first made in the following way: Food being put into a basket or a scoop net, the young are thereby enticed and caught, and are distributed into two ponds. The first pond is at the same time completely cleaned from everything pernicious and replenished with water. The selection is sometimes made while catching the fish with a basket or a scoop net from the new pond, when an earthenware plate is put for this purpose into the basket (or the scoop net), the inside of which is covered with gauze. The caudal fin is

the criterion by which selection or rejection is made. If there is any marked diversity in the size of the fish, the large ones are separated from the small. Those selected are put into the pond lately cleaned, when their number is roughly estimated by measuring them with a teacup or a lacquered bowl. Twenty or thirty days later another selection takes place, in which the fish are chiefly classified according to size. As at this stage those destined to be white can be distinguished from those to be dappled, the former are caught and sold off. Between this time and the following August all the fish are cleared off by selling, except 300 per tsubo of the ponds, it being possible to find buyers for the fish grown to one sun (3 centimeters) or over.

Toward the end of March the next year, 4,000 of the fish deemed best are retained and the rest sold off. From that time forward selection is made once a month during the following April, May, and June, and every time 1,000 fish are eliminated, commencing with the most inferior, until 1,000 are left at last for breeding purposes. Making allowance for loss from various causes and deducting 2 per cent from the above number, 800 fish may remain.

WAKIN, DEMEKIN, AND DEME RANCHU.

The wakin is never so much prized as the ryukin, but on account of its large size, besides being healthy and strong, it is kept in a garden pond. In this variety, the tail should be thick and widely spread, the rays invisible and the dapples not merged into one another, while the contrary is the case with the ryukin in this last respect. The method of its culture is the same as that of the ryukin.

Of the demekin those dappled with three of four colors are highly prized. Either the vermilion dapples or the black patches should be pronounced. In some the black pigment gives the color of ink, while others have the color of steel, like that of the crucian carp. In the former the color is permanent, but in the latter it fades into yellowish red in a year or two, and such a color as this last is worse than a uniform red. The caudal fin should be long and widely spread. The eyes, right and left, should protrude symmetrically. Those which protrude but little are not regarded with favor. Goldfish of this variety swim about, not in groups, but singly, which is not the case with the goldfish long known in Japan.

The deme ranchu is colored all over the body either with yellowish red or black pigment, or yet dappled with black and red. This variety remains most of the time at the bottom of the pond resting on the belly, and scarcely ever swims. It does not live in groups; even less so than the demekin, and it very seldom spawns. In cultivating this variety, the breeders follow the same method as with the ryukin.

Thus far as regards the culture of goldfish in Tokyo. I shall now describe the method of culture pursued at Koriyama.

METHODS OF CULTURE IN KORIYAMA.

There are but few trustworthy records giving information on goldfish breeding in remote times in Japan. Tradition has it that during the Hoyei era (1704–1710), a certain Sato Sanzaemon set up as a goldfish breeder at Koriyama and commenced to cultivate the fish in a mud pond. It is said that he pioneered the industry in that locality.

The principal varieties of goldfish cultivated at Koriyama are the oranda shishigashira, the wakin, and the ranchu. The ryukin was most extensively cultivated there until fifty years ago, but it has since been replaced by the oranda shishigashira and is not much reared at present. The demekin is not wholly uncultivated at Koriyama but no great attention is paid to it.

The dimensions of a pond at Koriyama do not vary with the different varieties of goldfish. It is usually oblong in form and measures 10 ken by 3 ken, i. e., 30 tsubo (99.2 square meters). This is a size most convenient for the purpose of efficient fertilization. Formerly a depth of 1 shaku 5 sun (45 centimeters) was given to the pond, but it is now increased to 2 shaku (60.5 centimeters) in order to protect the fish from the sun's heat or atmospheric changes. The only drawback in this increased depth is that injurious gases are thereby generated from the bottom, especially when a large quantity of fertilizer is put into the pond.

COLLECTION AND CULTIVATION OF FISH FOOD.

The most noteworthy thing in connection with goldfish breeding here is the attention paid to rearing as well as collecting mijinko. These small crustacea are caught in a bag 20 to 25 shaku (6.0 to 7.5 meters) long, with a diameter of 2 shaku (60.5 centimeters) and made of "tenjiku kanakin" (a kind of calico) with fine meshes, varnished with the astringent obtained from unripe persimmons, or with the extract of oak-tree bark. For two weeks after hatching the fish are fed with the smallest of mijinko, which have been sifted. For another fortnight a larger kind of the crustacea is also given. When mijinko can not be obtained recourse is had to the yolk of boiled eggs, well pulverized. But the latter compares unfavorably as a substitute.

Usually 40 days, but when it is warm, 30 days, prior to removing the newly hatched fish to another pond, soy lees packed in a straw bag are immersed in the bottom of the second pond with a view to producing mijinko. To determine properly what quantity of fertilizer is to be placed in the pond is very difficult. In the case of a newly made pond, 50 kamme (187 kilograms) of soy lees mixed with 4 or 5 ka (59.8 kilograms) of human excrement in liquid state

are poured over the bottom when it is not yet filled with water. When the bottom is sufficiently exposed to the sun, the pond is replenished with water, which in a few days presents a green color on account of the algæ produced there. Even after the young fish are put into the aforesaid pond it must be fertilized every other day. When they are fed with mijinko obtained elsewhere, one sho (0.4 gallon) of the crustacea is given every day in the case of a pond of 30 tsubo (99.2 square meters).

This is what should be done with the fish when removed to a new pond after forty days from the time of their hatching. During these forty days they are kept in a concrete pond and are given mijinko in such quantity as may be deemed proper. Afterwards the number of mijinko in that pond is ascertained by immersing something like a white earthenware plate in a corner of it, and a supply of food to the fish is kept daily increasing. Feeding the pond with fertilizer is intended for no other purpose than producing mijinko, with which the fish are to be provided without interruption.

The longer the fish are fed with mijinko the better it is for them. As there is, however, a limit to the supply of mijinko, that wholesome food when the young are grown to 4 or 5 bu (1.2 to 1.5 centimeters) gives way to the *Viviparus* (a kind of mollusk found generally in the rice fields) pulverized, or the dried chrysalides of silkworms pounded and mixed with starch. As it is during the three months of June, July, and August that the fish increase in size with great rapidity, the most abundant supply of food is given in this season of the year. The extent to which the fish are to be fed, indeed, is judged by the color of water in the pond. When the water is green and turbid, it shows that the supply of food is plentiful; when it is green and transparent, the supply is insufficient. The same is the case with all other colors.

ORANDA SHISHIGASHIRA.

A concrete pond is used for hatching the oranda shishigashira. It is 12 shaku (6.1 meters) long by 5 shaku (1.5 meters) broad with a depth of 7 to 8 sun (21.2 to 24.2 centimeters). The eggs having been deposited on bundles of willow-tree roots placed in a mud pond, about 50,000 or 60,000 are put into the above-mentioned concrete pond to be hatched. The water is removed without fail every four or five days, and is even changed every other day when the weather is warm. The first selection of the fish takes place after twenty-five days from the time of their hatching, when they are about 2 bu (0.6 centimeter) in length. About 20,000 of the then superior breeds are retained, the rest being eliminated, i. e., sold off. If the number of those first hatched suffices, it is most satisfactory, but if it does not, those hatched later are added. If sickness or other cause reduces this number, those hatched still later are used also. In that last case the fish are made to spawn even in midsummer. Forty days from the time of

their hatching they are put into a mud pond in the proportion of 300 fish per tsubo. The next selection is not made until the fish put on new colors at the end of July or the beginning of August, when those which are uniformly white or unsatisfactory in the form of the tail are sold at a nominal price. That the best kind of the variety may be obtained, however, two more selections are to be made, the character most highly prized being the form of the caudal fin. In Tokyo and Nagoya the four-lobed tail is regarded with preference, while Koriyama is content with the three-lobed tail, the four-lobed tail, or the bag tail, if only it is symmetrical in form. The head should be broad in front. The protuberances which are in three years developed on the head should be like a large well-proportioned flower of the tree peony and should not be small. In some localities, such as Kii, Hiroshima, Awa, and Sanuki, there is a variety called simply "shishi" (lion), which is brass colored and has a short tail. Not a few of this variety are found to be uniformly colored. Generally speaking, those which are satisfactory in the form of the head have the tail abbreviated; seldom are the fish perfect in both respects.

There was formerly neither oranda shishigashira nor ranchu having variegated figures on the back. Such varieties, however, have been occasionally produced since the twenty-second year of Meiji (1889), and their descendants have been studiously used for breeding purposes. Both varieties are now extensively produced and highly admired.

The young oranda shishigashira are first put into a mud pond in the proportion of 300 fish per tsubo, but those white in color and abnormal in form are eliminated, and from this and other causes the numbers are by autumn reduced to one-half of the number originally put into the present pond. These are left alone till the following spring, when they are put up for sale. They attain by that time the size of 1 sun 5 or 6 bu (4 to 5 centimeters) in length. When it is desired to produce fish of a greater size, the number of young first to be removed to a new pond after hatching is reduced from 300 to 100, and these attain the size of about 2 sun (6 centimeters) in the same length of time as before. In the third year they grow to 3 or 4 sun (9 to 12 centimeters), in the fourth year, to 6 sun (18 centimeters), in the fifth, to 8 sun (30 centimeters), and in the sixth, to 1 shaku (33.3 centimeters). In fact, it is known that in the last-mentioned year they sometimes attain to the minimum size of 1 shaku 2 sun (36.5 centimeters). Furthermore, for the purpose of producing breeds of a great size, the fish having a good natural constitution and a well-formed head are selected from the six year old stock as parent fish, and breeds are put into a pond in the proportion of 6 or 7 per tsubo. Selection is again made in the following year and the rate is further lessened to 2 per tsubo. The fish are fed with 2 kamme (7.5 kilograms) of *Viviparus* and 500 or 600 momme (1,875 to 2,250 grams) of the chrysalides of silkworms pounded and mixed with starch (of

wheat). All ponds are so made that they can be drained at any time to prevent the generation of poisonous gases. Usually twice a year, viz, in March or the beginning of April, when the young are about to be removed to another pond, and at the end of autumn when the fish are going to be put into a hibernacle, both these ponds, prior to receiving them, are drained and dredged and then exposed to the sun's rays for four or five days. Any place where the water gushes forth in the ponds should be exposed longer. It is usual for these steps to be taken twice a year as stated above, but the more this is done the better it is for the health of the fish; it would be best to do it even once a month. When the fish come up to the surface of the pond to breathe in warm weather before sunrise and go down afterwards into the water it shows that they are in good health.

RANCHU.

The ranchu is chiefly cultivated in a concrete pond, though in small numbers. The number of ranchu to be put into a pond after hatching is one-half the number of oranda shishigashira, and the amount of fertilizer used is also half the amount of that used in the case of the latter variety. When put into a mud pond, the method of culture of the ranchu does not differ from that for the oranda shishigashira, but when reared in a concrete pond it is essential that the fish should be constantly supplied with fresh water. Hence the necessity of entirely renewing the water once every day. An amateur breeder would be likely to partially change the water to prevent a sudden change of temperature in the pond; but nothing is better than entirely replenishing the pond with fresh water of the same temperature as before. The fish are fed only with the larvæ of mosquitoes.

In a concrete pond of the aforesaid size are generally placed 100 fish under 1 year, 30 under 2 years, 10 under 3 years, 4 under 4 years, or again 4 under 5 years, but if these numbers were reduced better results would be obtained. It is good for the fish to be constantly supplied with food. Earthenware plates are not used for this purpose as in Tokyo, except for the time being after the fish are first put into a mud pond. There is one advantage in this method of feeding them without earthenware plates: they are naturally made to thrust their snouts in quest of food into the bottom of the pond, with the result that the bottom remains free from gases. If the number of fish under 1 year to be put into a rearing pond is reduced below the normal quantity above referred to (i. e., 100), they can be made to attain the size of 2 sun 5 bu (7.5 centimeters) at the end of the year, while keeping to that quantity they attain in length only 1 sun 5 bu (4.6 centimeters) in the same length of time, 2 sun (6 centimeters) at the end of the second year, 3 sun (9 centimeters) at the end of the third year, 4 sun (12 centimeters) at the end of the fourth year, and 5 sun at the end of the fifth year.

WAKIN.

In the case of the wakin, twice as many as of the preceding variety are cultivated in a pond. When put into a miniature pond they are most lively, but do not live long.

ARTIFICIAL COLORATION.

Various designs are artificially produced on the back of goldfish at Koriyama. Dilute hydrochloric acid is applied to the part where certain figures are desired to be produced. But the scales along the margin of the intended figures (such as badges or flowery patterns) being but partially colored, the results are not very satisfactory. This artificial coloration is best attempted in August or September, in the early morning. When the fish are purely red, the discoloration makes them very unsightly; besides, the color of the head can not be changed. For the purpose of artificial coloring, the water of the pond in which the fish are kept should in the first place be completely renewed and then they should be abundantly supplied with food. When they grow plump and fleshy the figures are put on. This practice has been known from remote times.

INTEREST AND VALUE OF GOLDFISH TO THE JAPANESE.

On account of its beautiful form, its fine bright color, and graceful attractive motion when swimming, the goldfish has been for hundreds of years a great favorite with the people of Japan, and now different varieties are cultivated almost all over the Empire. In Hokkaido it is very difficult for the fish to survive the winter, owing to the intensely cold climate, and they are hardly ever hatched and cultivated there. Yet the favor with which they are regarded is extremely great and they are yearly brought there from Tokyo without number in the beginning of summer.

Such is the interest with which goldfish are regarded in Japan, and they are, moreover, admired by every class of the Japanese people. Some are kept in an artificial lake in a garden, some in tanks of various forms, others suspended in a glass globe from a ceiling, still others put into the pond of a miniature garden, and so forth. The kind and quality of the fish naturally vary with the class of people by whom they are kept. Those kept by persons of wealth and position are superior breeds specially selected, while people of limited means, holding in regard healthy and strong ones, prefer the wakin and the ryukin to others. Those enjoyed by children are mostly what are called "dregs" and often sold on fête days, which are many in Tokyo and other towns.

Although the goldfish is so extensively cultivated in Japan, as has been stated above, yet its value from a commercial standpoint can not be said to be

very great. The inferior breeds are sold at 1 sen (half a cent) a piece, while the superior ones fetch a price of only 50 yen ($25) a pair. On rare occasions, however, 200 or 300 yen are paid for a single pair. In costliness the ranchu ranks first, the superior breeds of the oranda shishigashira are also of great value, and the ryukin comes next. The number of the last variety yearly exported from Yokohama and Kobe is great.

As already mentioned, the ranchu is regarded with special favor in Tokyo. An exhibition of this variety is held there every year in autumn by lovers of the fish, for the purpose of having the merits of their exhibits determined, and a successful breeder to whom an award of merit is made prides himself upon it. The exhibition lasts two days, on the first of which are examined the grown-up breeds and on the second the young in the first year. Being developed in color and form, the former naturally attest the extent of skill in the breeders and their value can be known at a glance. The latter are those hatched only in the preceding spring and as yet little developed in every respect; but these, after all the care lavished upon them by breeders, are to appear again fully grown up for contest at a future show, and on that account are full of interest and promise. The examination of fish in an exhibition is made in a shallow tub containing a white earthenware plate in the center. Two ranchu being placed in the plate are examined by connoisseurs as to their shade, dapples, and the form of the tail and body. Those perfect in every respect are awarded the "first best," and a list of the exhibits made in the order of their merits is given to the public. Every time the classification is made amid a stormy debate by the examiners. No positive criteria exist to guide one in the examination of the ranchu. Nevertheless, those uniformly bright red are considered the best, so far as coloration is concerned. Those perfect in form, however uniformly white they may be, are counted tolerably good. The variegated ones are generally unpopular; but in Osaka and its vicinity, those having fine dapples are greatly appreciated, especially if the head is of a bright red color. A ranchu having either a white body and bright red fins and mouth, or a bright red in color in both cheeks, is also admired. Every one of the breeds exhibited has its own name, which is given in the aforesaid list with that of the owner. Those who participate in the show are mostly nobles, wealthy merchants, and others in comfortable circumstances. On such occasions the very best breed fetches a price of 200 or 300 yen, but not one in ten thousand commands such a high price. The exhibition takes place chiefly in Tokyo but it has recently come to be held in Osaka also. Not a few goldfish breeders with fish of their own culture now come from localities lying far beyond Hakone to take part in a Tokyo exhibition. The reason why the exhibition is held in autumn is that the goldfish puts on the most brilliant colors in that season.

THE COMMERCIAL SPONGES AND THE SPONGE FISHERIES

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of one hundred dollars in gold offered by John K. Cheyney for the best presentation treating of the methods of the sponge fisheries, the influence of such methods on the supply of sponges and the most effective means of conserving the sponge grounds

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THE COMMERCIAL SPONGES AND THE SPONGE FISHERIES.

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INTRODUCTION.

Sponges are known to the general public almost solely from their use in the toilet, one of their minor applications. They are vastly more valuable in the arts. In many trades they are practically indispensable, and despite long effort and the ingenuity of inventors no satisfactory substitute has ever been produced and it is doubtful whether one can be found. The properties that give a sponge its value are many, they are found in combination in no other natural or artificial product, and the perpetuation of the sponge supply is of no small moment to civilization.

The commercial sponges and their congeners are of wide distribution in the warmer waters, but the fisheries as at present developed are almost entirely restricted to the Mediterranean Sea, the Caribbean Sea, the Gulf of Mexico, and waters contiguous to these. Recently attempts have been made to establish a fishery in Australia, within the last year (1908) a few sponges have been shipped from the Philippines, and it is stated on rather vague authority that sponges resembling a poor quality of the Mediterranean toilet are now being fished on the coast of Madagascar. But the product of these regions is negligible in the markets of the world.

The Mediterranean fishery is of considerable antiquity, and it now produces over half in value of the world's supply, though it is impossible to obtain accurate statistics for all countries on its border. The newer fisheries of the American coast produce by far the largest quantity, but a predominance of lower-priced kinds reduces the value to about three-fourths of that of the Mediterranean fisheries. The following table gives approximately the world's annual yield at the present time:

Mediterranean and contiguous waters (partly estimated)	$2,039,000
Florida, 1903–1908 (average)	555,000
Cuba, 1903–1906 (average)	374,000
Bahamas, 1900–1905 (average)	520,000
Other localities (estimated)	10,000
Total	3,498,000

This paper, in conjunction with another on sponge culture,[a] is designed to furnish a brief, but fairly comprehensive, review of present knowledge of commercial sponges, the geographical distribution of the fisheries, the methods employed, the effects of those methods upon the natural beds, and the measures which appear to be necessary for the protection and conservation of the supply.

Concerning the qualities and the characteristics that distinguish sponges of different grades and values, the consumer is probably less informed than in respect to any other natural product in general use, and he is frequently imposed upon. In many cases it is difficult for even an expert to identify the different local varieties, though there is much difference between them in the qualities that fix their value for practical use. The distinctions by which the various grades can be recognized are, moreover, such as to be difficult or impossible of expression in words. For these reasons the illustrations of this paper have been prepared, with especial care, to supplement the descriptions. The sponges pictured are typical specimens of the numerous local varieties and without exception represent sponges now on the market.

As the purposes of the paper are mainly practical and economic, the discussion of the scientific status of the various kinds of commercial sponges, their general biology and morphology, has been reduced to the minimum necessary for a proper understanding of their nature and the problems which must be solved before the regulation of the beds can be placed on a rational and effective basis. The question of the scientific classification of the commercial varieties will be taken up some time in the future, when the accumulation of material and certain experimental data may offer some guarantee of better results than have been attained previously. The subject is one of extreme difficulty, and it is not believed that it can be successfully attacked without the assistance furnished by a well-equipped laboratory in the vicinity of the sponge grounds.

I. THE LIVING SPONGE.

To most persons familiar only with the sponges of the shops, the animal as it comes from the sea would be entirely unrecognizable. (Plate XXVIII.) It is a solid looking, rather slimy feeling, fleshy body, varying in color from light-greyish yellow through a considerable range of browns to black, and in form either cup-shaped, spheroidal, or cake-shaped, according to the species, its age, or the environment in which it grew. In general, in appearance and consistency and the manner in which it cuts with a knife, a living sheepswool sponge is not unlike a piece of beef liver, perforated with holes and canals.

[a] Moore, H. F.: A practical method of sponge culture, Proceedings International Fishery Congress, in Bulletin U. S. Bureau of Fisheries, vol. XXVIII, 1908, p. 545–585.

The sponge of the markets is merely the skeleton, the supporting framework, which gives strength and form to the soft gelatinous tissues of the living animal. It is composed of a substance similar in general chemical and physical properties to silk, horn, and chitin, the basic material which forms the shells of insects and crabs. This material is distributed in a fibrous network, usually in accordance with a definite general pattern in each species; the diameters of the fibers, the sizes of the meshes, and the relations existing between the several parts lying within more or less well-fixed limits. In addition, the main fibers always contain more or less foreign matter, sand grains, spicules, etc., embedded in their substance in the form of a core.

A casual examination of the living sponge will show it to be covered by a well-defined skin raised at more or less regular intervals into blunt little cones over the ends of the skeletal fibers, by which it is supported. Distributed over the surface, sometimes rather generally, sometimes locally, are sieve-like membranes, whose small pores lead into cavities lying just below the skin. From these cavities canals lead into the substance of the sponge, opening by numerous minute pores into as many small pear-shaped chambers, which from their opposite ends discharge through larger openings. If the canals leading from these could be followed, it would be found that, uniting with their fellows, they gradually increase in diameter until they open upon the surface of the sponge in one of the large conspicuous pores known as "oscula," or, as the spongers call them, "eyes." The oscula are sometimes more or less generally distributed, sometimes localized, according to the species, and each is surrounded by a smooth membrane capable of expanding or contracting in such manner as to vary the size of the opening.

This canal system is one of the most important organs, as well as the most characteristic feature of the sponge. It is the sole means of feeding and practically the sole means of respiration. Its method of functioning is as follows: The pear-shaped chambers described above are lined with cells of a peculiar character, collar cells, as they are called, each provided with a little lash or cilium projecting into the chamber and beating rhythmically in such manner as to set up a current in one direction. The mechanical effort of each is feeble, but the joint action of the untold numbers of such cells in a sponge sucks water through the small orifices in the surface, first described, into the ciliated chambers and in turn forces it into the successively larger canals until it finds vent through the oscula. The water, with its contained food and oxygen, therefore enters the sponge through the small superficial pores and leaves it by the large ones. Excluding from consideration the foreign bodies, shells, coral, etc., which the sponge often overgrows and surrounds, the whole interior, save the skeleton and spaces of the canal system, is occupied by tissues which are neither of many

varieties nor strongly differentiated. There are certain cells called "spongoblasts" which secrete the material of which the skeleton is composed. Collar cells and other epithelial elements line the ciliated chambers and the several canals with which they are in communication. The outer surface and the subsuperficial or subdermal surfaces are covered with a single layer of flat cells.

The main portion of the fleshy part of sponges is made up of what is known as ground substance, a jelly-like material, similar to that found in the umbrella of jelly fishes, without cellular structure, but containing connective tissue cells. Muscle cells are found in the skin, the canal walls, and the membranes around the peripheral pores, and nervous and sensory cells occur in association with them, an explanation of the limited sensitiveness and contractility which are noticed in handling live sponges.

Concerning the life histories of commercial sponges we know but little. In some species, at least, the sexes are separate, the females greatly preponderating, and the young are produced mainly if not solely from eggs. The young are, for a time, minute free-swimming organisms which may be carried considerable distances by the currents, and they are still very minute when they at last settle down for permanent attachment. At this stage, like oyster fry, they are liable to be covered and suffocated by comparatively thin deposits of sediment, and the object to which they can successfully attach must be hard and clean. It follows from this and from the fact that much of the sea bottom is more or less covered with soft deposits, however thin, that a vast majority of the young sponges fall on unsuitable bottom and are lost. This accounts in many cases for their irregular and sparse distribution on many rocky bottoms which superficial examination would indicate as favorable. The natural bars are undoubtedly capable of supporting a much heavier growth than they usually bear, and if partially grown sponges could be placed on them, as is proposed in the system of sponge culture elsewhere described, their productiveness could be enormously increased, as these deposits of sediment, fatal to the spat, would prove innocuous to larger individuals.

The rate of growth of sponges under undisturbed natural conditions is not definitely known, but the experiments recounted in another connection[a] indicate that it is slower than is generally supposed by the spongers. There is very good reason to believe that the average annual increase in diameter of sheeps-wool sponges in Florida waters is not greatly in excess of 1 to 1¼ inches. The rate varies somewhat in different localities and under different conditions. The average 6-inch sponge is probably not far short of four years old, though possibly the early growth may be more rapid than the experiments indicated for later stages.

[a] Moore, H. F., op. cit.

Commercial sponges are very susceptible to the influences of environment, and when transplanted from one place to another speedily change in character. If grown in the midst of vegetation they become coarse and open in texture, of irregular shape, with long superficial processes and protruding oscular tubes. If raised high above the bottom the texture becomes more dense than that of neighboring bottom-grown specimens. Individuals suspended artificially on wires or growing naturally on gorgonians (sea feathers) tend to become spherical, and those torn loose to roll freely over the bottom assume the same shape, but develop harsh, very tough surfaces.

The commercial sponges of Florida, especially the sheepswool, yellow, and velvet sponges, can not live in water which falls for any considerable period much below oceanic salinity. Observations made in connection with sponge culture and on the natural beds indicate that the allowable minimum of salinity is reached when the water falls to a specific gravity of about 1.019 or 1.020. Exposure to the air is tolerated for considerable periods, especially during cool weather, and sponges grow naturally in situations where they are occasionally bared at low tide. From this extremely shallow water, the distribution of commercial sponges in Florida extends certainly to depths of 110 feet and probably to much deeper water, as in the Mediterranean, where they range to a depth of 500 to 600 feet. Of the food of sponges practically nothing is known. That it is taken in through the canal system and that it must be in a finely divided state is practically certain, but of what it consists and by what tissues it is absorbed is unknown. The so-called "roots" of sponges perform no other purpose than that of anchorage and are not special organs of nutrition like the roots of plants.

There appear to be few, if any, important natural enemies of commercial sponges, though perhaps they are subject to the attacks of microscopic organisms, producing certain epidemics which are ordinarily attributed to other causes. Crabs are ofter found in cavities burrowed in their substance, but despite popular belief to the contrary, I do not think that the chambers are actually excavated by the crabs. They probably find them ready-made and when they crawl in the pressure of their shells prevents filling up, or possibly expands the cavity.

II. REQUISITES OF A COMMERCIAL SPONGE.

The qualities of the skeleton affecting the commercial value of sponges are color, size and shape, softness, fineness, durability, resiliency, and absorptiveness.

Color.—The color is the consideration of least intrinsic importance, though for purely esthetic reasons it exerts a considerable influence on the price. The most desired color varies somewhat with different classes of sponges, but in general the lighter tones are preferred. For bath purposes a pale yellow appears to be most in demand, and this requirement is catered to by various processes

of artificial bleaching. Sponges of the same species will frequently differ in color in different localities. The sheepswool of the Florida Keys, for instance, has a deep reddish brown "root" and interior, while this is lacking in Rock Island specimens, and the latter are also more grayish externally. As these color characteristics are correlated with differences in other qualities, especially durability, they are of value in distinguishing the grades. In general the sponges of commerce, i. e., the skeletons, are yellow, light brown, or brownish gray.

Size and shape.—The most desirable size and to some extent the shape depend upon the purpose to which the sponges are to be put. For surgical purposes small ones are required, for toilet use a medium size, while for cleaning vehicles and cars a large sponge holding a considerable quantity of water is necessary. Sponges up to about 8 inches in diameter are commonly used entire and called "forms," but above that size they are usually cut into pieces and known commercially as "cuts." Most or all American sponges of a less diameter than 4½ to 5 inches are of comparatively little use and value, but the Mediterranean grades find a market in even the smallest sizes. Some species possessing all the other requisites are debarred from the markets solely by their shape.

Whatever the form of a sponge, to be of commercial value it must be regular, more or less massive, and free from long processes and digitations. Certain of the inferior Cuban sheepswool sponges are about the only exception to this rule, and in the case of these the long, teat-like projections which carry the oscula at their summits are usually cut off more or less close to the massive base from which they rise. Under normal conditions all commercial sponges are either spheroidal, cake shaped, conical, or cupped. The gradations between these shapes are infinite and each species presents great variety, due to age, environment, and perhaps individual tendency. The shapes assumed by the various species will be considered in the descriptions of the several commercial varieties.

For general purposes the most desirable forms are the spheroidal and cake shaped. In applying the glaze to pottery, however, and in other similar work, a smooth, flat surface is desired, and this is generally obtained either by cutting up the more massive forms or by taking pieces from a smooth-surfaced cup-shaped sponge like the Mediterranean elephant's ear. The American rough-surfaced conical and cup-shaped sponges, like the Anclote grass, are usually cut, invariably so when they are of large size.

Softness.—The more desirable grades of sponges, other things being equal, are those which are softest, the cheaper, inferior grades being generally, though not always, more or less harsh. This quality depends upon the thickness and arrangement of the fibers, the amount of foreign matter included in them, and

the openness of the canal system. Sponges with comparatively slender fibers, with the microscopic meshes rather open, with a small amount of foreign matter included in the spongin, and with an open canal system, are the softest. Those in which the fibers are heavily laden with sand are invariably harsh.

Fineness.—Fineness depends upon the macroscopic rather than on the microscopic arrangement of the skeleton, though the slenderness of the fibers is a factor. The Matecumbe sheepswool is one of the softest of sponges, but its open structure makes it appear coarse when compared with Mediterranean kinds. Fineness in the same species varies more or less with the environment under which the individual is produced.

Toughness and durability.—These qualities depend upon both the microscopic and the macroscopic characters of the sponge skeleton, and also apparently to some extent upon its chemical properties. These factors vary with the sort or species and in the same sort are subject to environmental differences. In any given species the looser the general structure and the larger and more numerous its canals and subdermal spaces, the more easily it is torn and the sooner it breaks down in use. The loose, open-textured sheepswool sponge of Biscayne Bay is much more quickly destroyed in a given service than is the denser Rock Island variety. That chemical factors also enter into the matter is apparently indicated by the greater tenderness of the red-rooted Key sheepswool as compared with equally open selected specimens from the Bay grounds not exhibiting this peculiar color.

Resiliency.—Upon this quality depends very largely the value of a sponge for economic purposes. Sponges are generally more elastic when dry and more compressible when wet, and if under the latter condition they return promptly to their original shape when the compression is removed they are more useful than if sluggish or "soggy" in their reaction. Resiliency depends upon the size of the fibers and the arrangement of the microscopic mesh work, and also upon the thoroughness and manner of cleaning. Specimens poorly cleaned and containing much "gurry" are sluggish in returning to shape after compression.

Absorptiveness.—This quality depends upon a combination of softness, fineness, and resiliency, and is the fundamental property upon which the usefulness of a sponge depends. A sponge that takes up little water or that absorbs it slowly or that drains quickly after it is removed from water is inferior for all purposes to one having the converse properties.

Water is absorbed by the capillarity of the mesh work, and the finer and closer this is the more water taken up and retained. The fibers themselves absorb a small amount of moisture, but this is not available for mechanical purposes, as it is released by evaporation only. Resiliency assists in absorption by promptly opening the meshes after compression, so that they act mechanically like so many minute pumps. The most copiously and quickly absorbent

sponges have fine meshes, slender fibers, and generally close texture. Large canals and cavities decrease the amount of water which can be absorbed in proportion to the size of the sponge, though they do not necessarily affect the rapidity with which it is imbibed.

III. THE COMMERCIAL VARIETIES OF SPONGES.

Both the scientific and commercial classifications of economic sponges are much confused and unsatisfactory and the two are mutually contradictory. Sponges considered by zoologists as of the same species or variety are separated into different commercial grades or species often differing widely in value, and, conversely, the trade often recognizes under the same name species that are undoubtedly zoologically distinct. These animals are so extremely plastic and susceptible to the influences of local environment, changing form, appearance, and character so completely under changing conditions, that it appears hopeless to expect a satisfactory scientific arrangement until present methods of research and nomenclature are completely departed from. In the present paper, designed as it is for economic purposes, the commercial classification is followed, the probable scientific names of the sponges described being indicated but incidentally.

In the following list are given the names commonly used in several languages, but the commercial classification is much more complex than is here indicated. All of the principal kinds are further subdivided in the markets according to geographical origin, quality, and even the methods by which they are taken. Among American sponges, in addition to the various geographical and local designations we have "forms," "cuts," and "seconds," while in the Mediterranean there are "fines," "commons," "seconds" (écarts), plongées, harpoonées, etc.

COMMON NAMES OF COMMERCIAL SPONGES IN DIFFERENT LANGUAGES.

English.	French.	Cuban.	German.
Sheepswool; wool	Indienne	Hembra.	
Yellow	Boulet	Macho fino.	
Velvet; boat	Havanne	Farao; aforrada.	
Grass	Afrique	Macho cueva.	
Silk grass		Macho peludo.	
Glove		Macho dulce; macho guante.	
Reef; "West India surgeon's"	Fine Antille	Macho dulce.	
Hardhead; American zimocca	Fine dure	Machito fino.	
Turkey cup; Turkey solid	Coupe turque; fine douce de Syrie; de Archipel.		Feiner Levantiner-schwamm.
Toilet	Fine douce de Adriatic		Levantinerschwamm.
Zimocca	Chimousse; fine dure de Syrie; fine Grecque.		Zimokkaschwamm.
Bath; honeycomb; horse; Venetian, etc.	Fine de Syrie; fine blonde; commun de l'Archipel, etc.		Badeschwamm.
Elephant ear; wash rag; laparotomy; flat potter's.	Oreille d'elephant		Ohrenschwamm; Mundschwamm; Levantinerlappen.

Common names of commercial sponges in different languages—Continued.

English.	Italian.	Greek.	Various.
Turkey cup; Turkey solid		Melati; fina eklekta	Abiund (Syria).
Toilet	Spugne da bagno; Levantine.	Melati.	
Zimocca	Spugne zimocca	Tsimouka	Achmar (Syria); tsimouri (Turkey); hadjemi (Tunis).
Bath; honeycomb; horse; Venetian, etc.	Spugne da equine	Hondra (Hydra); kapadika (Calymnos).	Cabar (Syria).
Elephant ear; wash rag; laparotomy; flat potter's.		Psathouria; lafina (Hydra); lagofita (Kalymnos).	

SHEEPSWOOL OR WOOL SPONGES.

Hippospongia canaliculata gossypina.

The sheepswool sponges, which are found in the Gulf of Mexico, the Caribbean Sea, and the adjacent parts of the Atlantic Ocean, all appear to belong to this variety, with the possible exception of certain specimens from Cuba, concerning which I am uncertain. They exhibit wide local variation, are very sensitive to environment, and when transplanted from one locality to another undergo marked change in character. The whole surface of the skeleton is tufted with fascicles of fibers, which are longer and more fimbriated in the shoal-water specimens. The oscula are confined to the upper surface, are large and comparatively few in number. They are usually surrounded with a circle of tufts and are often slightly, sometimes enormously, elevated on cones or tubes. The color of the living sponge is black, becoming brownish at the base. These sponges grow to a large size, 18 inches or more in diameter, are soft, absorbent, very durable, and of good shape. They are unequaled for general bath purposes and for use in the arts. They are employed generally for cleaning carriages, cars, and other highly polished surfaces where size, softness, durability, and great capacity for holding water are required. The larger perfect forms are used as gun swabs in the army and navy, or are divided and sold as "cuts" for use by tile and brick layers, painters, potters, and other artisans. The market varieties are as follows:

Florida Rock Island (pl. XXX and XXXI).—These, the best and highest-priced sponges of North America, are found in the Gulf of Mexico, on the west coast of Florida between Johns Pass and St. Marks. They are generally rather flat and with a broad base, closely knit, soft and strong. The surface color is grayish brown and the root and interior are little tinged with red. Those from deeper water are superior to shallow-water specimens in texture, density, and durability.

Florida Key wool (pl. XXXII and XXXIII).—This variety comes from the Key grounds elsewhere described, and is next in value to the Rock Island, which it surpasses in softness, especially if from near Matecumbe Keys, but does not equal in

strength, durability, or capacity for holding water. The surface color is paler, and the interior and often the insides of the oscula and the surface channels are colored a rather bright red. The surface is generally well felted, but the interior is more open and the fibers weaker. It tends to grow proportionally higher than the Rock Island sponges, especially when young, and the base is narrower, an inverted pineapple shape being common.

Bahama wool (pl. XXXIV and XXXV).—This is generally inferior to either the Rock Island or the Key wool, being coarser and more open and less durable and absorbent. The softest and best specimens come from the vicinity of Abaco. The shape is generally rather flat and the upper surface much tufted. Those from the vicinity of Andros Island are generally rounder than from other parts of the archipelago and the lamellæ tend to become thicker and less tufted on their free edges, sometimes remotely resembling the velvet sponge.

The Bahama wool sponges are pale yellow superficially and those from some localities have pale vermilion roots, while from other places they are practically untinged with that color.

Cuba wool (pl. XXXVI).—The ordinary Cuba sheepswool sponge has the same general characteristics as the Bahama variety, though inferior to Abaco specimens. Another form which is not uncommon, and which rather insufficient material indicates may be zoologically distinct from the other sheepswool sponges, has a rather flat incrusting base from which arise as many as thirty oscular tubes, sometimes reaching a length of 8 inches and 2 inches in diameter. These tubes swell somewhat toward their middles and tend to anastomose. Certain specimens indicate that this anastomosis may become so complete as to form fluted columnar sponges, twice as high as thick, with long stout oscular tubes on the upper surface. Lendenfeld does not recognize this as a distinct zoological variety.

Mexican wool.—This is the poorest of the sheepswool sponges, being coarse, loose of texture, much more tender than those that have been mentioned, and lacking in resiliency. Its surface color is dark-brownish gray and the root and interior are dull rusty red. In shape it is rather high, growing from a narrow base, and the oscular pores on the upper surface are large, open, and ragged. These sponges grow in the shallow waters, but it is stated that a type much superior is found in deeper water on certain parts of the coast, especially about the island of Cozumel.

Honduras wool.—On the coast of British Honduras is found a wool sponge which resembles the Mexican but is of slightly better quality. It has in most cases the same dull red or brown root and interior and the ragged oscular openings on the top. It has a lighter superficial color than Mexican specimens and appears to be rather stronger and more resilient. The sponges are usually irregular in shape, but this quality will probably be found improved in deeper water, those now taken being from the shallows.

Other localities.—Sheepswool sponges are taken to a limited extent commercially, or are known zoologically, in Honduras, at the island of Gonaves, Haiti, and at other places in the Caribbean. In the Philippine Journal of Science Seal describes a wool sponge from the Philippine Islands. The specimen he exhibited to me had the appearance of a Bahama sheepswool, and had been used for bath purposes. It is not unlikely that it was imported and not indigenous.

YELLOW SPONGES.

Under this name are known sponges of several zoological species and varieties, some of which receive also other commercial names, according to quality, size, and locality. Though differing much in details and special qualities, the yellow sponges have these characters in common: They are highly elastic and resilient, more so than any other American sponges with the possible exception of the Anclote grass, but they are harder than the wool sponges, less absorbent, and drain more freely. They are regular in shape, attractive in appearance, and grow to a diameter of about 18 inches, though this size is not common. The color is a rich yellow or yellowish brown, in some localities tinged with rust red or chestnut. The surface is never furnished with the long fibrous filaments characteristic of the sheepswool, but is covered with a nap of short hairs of uniform length and lying in a uniform plane. Though less durable than either the sheepswool or the velvet sponges, the yellow sponges are excellent for many purposes in the arts, and when bleached make attractive and soft, cheap bath sponges.

In the living condition they have smoother surfaces than the sheepswool, and are very dark brown on top, becoming yellower on the sides. The pseudoscula, vents, or "eyes" are in some varieties situated on the summits of low, rounded cones and in others lie in the general level of the upper surface. They are never surrounded by circles of fimbriated tufts as in the sheepswool, or compounded as in the velvet sponge. They are generally large and conspicuous. The commercial varieties of yellow sponges are as follows:

Florida Key yellow (pl. XXXVII, XXXVIII, and XXXIX).—This is the finest grade of yellow sponge, being softer and more durable than the Anclote yellow or the foreign varieties. The best come from the vicinity of Matecumbe Keys, where the common species is *Hippospongia equina elastica* Lendenfeld. This species is massive, cake-shaped, or, commonly, in the form of truncated cones attached by a narrow base. The lamellæ form a network lying in a uniform surface, are usually more or less thickened at their free edges and inclose numerous more or less uniform polygonal, circular, or meandering orifices. The surface of the skeleton is more continuous than in most of the other American sponges. The vents or "eyes" usually lie in the general level of the upper surface, but are sometimes, especially

in the larger specimens, raised on soft rounded cones or craters, the rims of which are generally interrupted in one or two places.

Another variety of Key yellow sponge is *Euspongia irregularis pertusa*, the common form of the Anclote region and Cuba, but this is inferior and less numerous.

Anclote yellow (pl. XL and XLI).—These consist almost wholly of the zoological variety last mentioned. They are more massive than the common Key yellow and are almost invariably attached by a broad base, from which the sides and tops rise in a more or less regularly convex surface, bearing low, broad cones or lumps on the summits of which the oscula open. The latter occur more or less over both sides and top, and are not confined to the upper surface as in the preceding species. The surface of the skeleton is more uneven and lumpy than in *Hippospongia equina elastica* and the superficial villi of fibers are longer and more tufted and frequently connected with one another by an irregular loose network of fine fibers.

These sponges are harsher and less compressible than the Key yellow and less desirable for commercial purposes.

Bahama yellow (pl. XLII and XLIII).—There are two common species of Bahama yellow sponges. One is *Euspongia irregularis pertusa*, the common Anclote form, from which it differs mainly in the more numerous oscula and the brighter yellow color of the skeleton.

The other is Hyatt's *Spongia agaricina* subsp. *dura*, which Lendenfeld apparently erroneously includes with his *Hippospongia equina meandriformis*. This sponge is more open in texture and less strong than the foregoing, but softer and more quickly absorbent. It is spheroidal in shape, though often one-sided on account of lateral attachment to the rocks, and the free ends of the lamellæ lie in a common surface as in the velvet sponge, but the exterior faces, instead of being felted and compact, are covered with a nap of loose-ended fibers, giving the whole surface a villous appearance and a rougher feel. The lamellæ consist of radially arranged club-shaped bundles connected by tangential buttresses or lugs, making a weak structure easily torn into radial shreds. The color is light brown. The oscula are single, not compound as in the velvet sponges, and are scattered over the upper surface and occasionally on the sides. Hyatt says that this is the "hardhead," but so far as I have observed the spongers now class it as "yellow." It appears to be particularly common near Andros Island.

The common yellow sponge of the Florida Keys is also found in the Bahamas, but does not appear to be generally included among shipments of yellow sponges.

Cuba yellow (pl. XLIV).—The common Cuba yellow sponge is the same species as the Anclote yellow, *Euspongia irregularis pertusa*, from which it differs mainly

in its brighter color and more cavernous structure, the oscula being more numerous and the blunt cones in which they are situated being separated in the skeleton by clefts entering rather deeply into the body of the sponge.

A variety similar to the Key sponge is found on the north coast of Cuba.

Honduras yellow.—This commercial variety, which comes from British Honduras, is the same zoologically as the Key yellow. It resembles the latter in surface appearance, but is harsher, less compressible, more open in texture, weaker, and less durable. In color it is bright yellow and it lacks the red root and interior of the Key sponge, from which it further differs in its habit of flatter growth. It is less harsh than either the Cuban or the Bahama yellow.

Other localities.—Hippospongia equina elastica is also found in the Mediterranean, where it is known as the horse sponge and otherwise, from Haiti and other places in the Caribbean Sea, and from Australia and New Zealand. *Euspongia irregularis pertusa* is known zoologically from Ceylon, Australia, and the Ellice Islands in the Pacific Ocean.

VELVET SPONGES.

The velvet sponges found in the straits of Florida, the Caribbean Sea, and the Bahamas, with the possible exception of the Jamaica sort, appear to belong to Lendenfeld's *Hippospongia equina meandriformis*. They are generally cake-shaped or spheroidal in form, somewhat broader than high and usually attached by a moderately broad base from which the sides swell out. The surface lacks the pointed or the edged tufts of the sheepswool sponge and the lamellæ are thickened at their free edges to form rounded or flattened cushions lying in the same plane and imparting a smooth appearance to the sponge. These cushions form either meandering ridges or flat brush-shaped tufts, adjacent ridges being often united by a felting of fibers producing a flat surface.

There are usually two, sometimes one, or three, large pseudoscula or vents on the upper surface. These are subcircular ragged openings, unlike those of any other commercial sponge, divided internally into numerous circular openings by irregular torn-looking septa. The color of the skeleton is light brown or dull yellow.

The velvet sponges are very soft to the touch and well deserve their name, but they are rather less compressible than the sheepswool and absorb water less quickly. They are also less durable and on account of the large holes or vents in the upper surface tear more readily. They are next in value to the sheepswool, though not differing much from the yellow in price. Following are the commercial kinds or grades:

Florida velvet (pl. XLV).—Found only on the reefs between Key West and Cape Florida, where comparatively few are taken. They are generally rather harsh and more or less torn and irregular.

Bahama velvet (pl. XLVI).—These bring the highest price, and the best, from near Abaco, are excellent sponges, very soft, of good shape, and moderately strong.

Cuba velvet (pl. XLVII).—These somewhat resemble the Florida sponges and are about equal to them in quality, though softer and frequently with the pads less compact and more tufted or "frizzly."

Honduras velvet.—The velvet sponges are the best that have been produced, so far, in British Honduras. They resemble the Cuban sponges more closely than those from other localities and appear to be about equal to them in quality. The rollers are hard but attached specimens are usually soft, though not so strong as Bahama specimens.

Jamaica velvet.—This differs much from the other velvet sponges. Its surface is more villous, the lamellæ less swollen on their free edges, and the shape tends to uprightness rather than rotundity, the older specimens especially being decidedly columnar. The most marked difference, however, is in the character of the vents, which instead of lying in subcircular septate depressions are grouped in single or double rows on the summits of branching crests which cross the tops of the sponges. The crests are formed of laciniated tufts somewhat like those which surround the vents or "eyes" of sheepswool sponges, and the individual openings are incompletely separated by ragged partitions as in the other velvet sponges. This arrangement results in a gash or tear more or less completely across the top of the skeleton. These sponges are harsher and otherwise inferior to the other velvet sponges.

Other localities.—This species is also known zoologically from Fernando de Noronha and Mauritius. A few inferior velvet sponges are taken on the Mexican coast but are usually included with the equally inferior sheepswool from that country. The few sponges taken about the island of Gonaves, off the west coast of Haiti, are principally of this species.

GRASS SPONGES.

Grass sponges are known commercially from Florida, the Bahamas, Cuba, Mexico, and British Honduras. They exhibit great diversity of shape and texture, but are all inferior in quality, lacking in durability, usually harsh to the touch, or, if soft, exceedingly tender. Most of them appear to belong to Lendenfeld's *Hippospongia equina cerebriformis*, but it is by no means clear that they are all of this variety or that they can be assigned to Hyatt's several varieties of his *Spongia equina*. None of the descriptions is sufficiently clear and complete to enable one to assign satisfactorily any large proportion of a considerable series. Following are the commercial varieties:

Anclote grass (pl. XLVIII).—These are the best of the grass sponges, but their shape is such that they are generally used as cuts. They are almost always

shaped like waste-paper baskets, inverted truncated cones deeply hollowed on their upper faces. The attached base is one-third to one-half narrower than the upper rim, the sides are almost straight or slightly convex, and the interior is hollowed out almost to the base in the larger specimens. The sides are sometimes nearly smooth, but are generally furnished with interrupted vertical ridges tufted at their upper ends, and are perforated by numerous orifices about $\frac{1}{16}$ inch in diameter. There are no oscula on the outer surface, although there are often irregular openings penetrating to the interior or even to the central cavity. The walls are thin at the rim of the vase and thicken toward the base. The oscula or vents are numerous and cover the whole interior of the sponge, excepting the vicinity of the rim. They are about $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and in the skeletons of older specimens are frequently converted into demicylindrical radiating furrows by the breaking down of the walls toward the cavity of the vase.

The skeletons are of a dirty brown color, harsh to the touch and highly elastic and resilient. These sponges are used by manufacturers of explosives, by masons, and for cleaning purposes about machine shops. They are especially useful where there is much oil, as greasy matter is more readily washed out of them than from any other sponge. For this reason, and on account of their harsh, stiff surface, they are useful for domestic purposes in washing pots and pans. They are found distributed over the entire Bay grounds.

Key grass (pl. XLIX, L, and LI).—These sponges are much more diverse in appearance than the corresponding grade from Anclote, are softer, more compressible, and much less durable. A typical form arises from a short narrow base or peduncle, spreading into a more or less hemispherical massive sponge with a flat or slightly concave top. The whole exterior is nearly covered by thin-walled oscular tubes about $\frac{3}{4}$ to 1 inch in length, the openings having a diameter of about $\frac{3}{16}$ inch. These tubes are directed variously, sometimes opening almost vertically downward, are sometimes deficient on one side, as in Lendenfeld's *Hippospongia canaliculata cylindrica*, and are not infrequently branched or Y-shaped. In some cases they extend more or less completely over the top of the sponge, but in the skeleton the latter is usually occupied by a great number of closely approximated orifices, about $\frac{1}{8}$ inch wide, separated by extremely thin walls, this feature being the principal reason for the great weakness of the sponge. In life this portion is covered by a membrane perforated by extremely minute pores, and even when the tubes extend over the top the space between is covered by a membrane of this character. In older specimens the oscular tubes on the outer surface become shorter and less prominent, though retaining the general characters just described.

In other cases the walls of the sponge become much folded and occasionally lobular, and the outer surface bears pencils, tufts, and vertical ridges of fiber,

which obscure the oscula and produce a cavernous interior. The walls in this type of sponge tend to become more vertical and the base of attachment broader, and as the top is often concave by the decay of the tissues, the sponge is more like the Anclote sponges, from which it is distinguished by its more irregular surface, its cavernous interior, thicker rim, and greater compressibility and tenderness of fiber, as well as by the presence of oscula on the outer surface. In other specimens the outer walls are smoother, with fewer and less conspicuous oscula, and the tufts of fibers are shorter and more uniform, exhibiting between them numerous small orifices. The whole top of these specimens, excepting a zone at the rim, is perforated by pores of uniform size, like those described in the first variety.

The Key sponges appear to be Hyatt's varieties *typica, plana, divisa,* and *caliciformis,* although his descriptions can not be recognized with certainty. The gradations are multifarious.

Bahama grass (pl. LII).—These differ strongly in general appearance from the Anclote and Key sponges and most of them probably, though by no means certainly, belong to Hyatt's variety *obscura.* They are generally round or cake-shaped and regular and are covered with fibrous tufts and pencils somewhat resembling those of the sheepswool sponge. The oscula are rather numerous, circular, and confined mainly, though not entirely, to the upper surface; but each has its own tube separated from that of its fellows, and there is nothing resembling the sieve-like upper surface of the Key sponges. The oscular tubes are thin-walled, of nearly uniform length in each individual, and the spaces between them are more or less completely filled with an irregular net or loose felt of fibers. In older specimens the soft superficial tufts often almost or quite disappear and the walls of the tubes break down, producing a rough, ragged exterior. The small specimens are light yellow, soft and compressible, the larger ones brown, harsh, elastic, stiff, and weaker in texture. Specimens from Andros Island, which grow principally on sea feathers, are nearly spherical, the oscula are less conspicuous, the surface tufts cushioned or palmate, and the texture weak.

Cuba grass (pl. LIII).—The Cuba grass sponges considered as a whole are intermediate between the Key and the Bahama sponges. In a given lot there are likely to be specimens resembling the *plana* type of Key sponges and others like the *obscura* type from the Bahamas with more or less intergradation. In old age the *obscura* type sometimes becomes cavernous and with a very irregular nodular surface. The quality on the whole is inferior to that of the same grade from the Bahamas.

Honduras grass.—The grass sponges from British Honduras appear to belong to the *obscura* type and resemble the coarser and harsher of the Bahaman

and Cuban sponges. There are occasional soft specimens, but in general they are so hard as to be of little commercial value.

GLOVE SPONGES.

This is the *Spongia graminea* of Hyatt, which Lendenfeld in his synonymy includes with certain Australian specimens in his *Hippospongia canaliculata*, var. *flabellum*, though the description which he furnishes does not apply, except perhaps as to the character of the fibers.

The shape is never "thickly flabellar," but almost invariably stoutly columnar, the sides being almost vertical and contracted at the top, which is usually flat. The base is almost as broad as the sponge. The appearance of this species is very characteristic, the sides being fluted with irregular vertical parallel ridges between which lie one or two rows of round holes from $\frac{1}{16}$ to $\frac{3}{16}$ inch in diameter. The ridges are frequently swollen on their free edges, which always bear long, ragged pencils of fibers. When the grooves are deep the ridges become plates, which viewed from above have a radial arrangement. They begin a short distance above the base and extend over the top of the sponge as far as the large open compound vents, which remotely resemble those of the velvet sponge.

Glove sponges are found on the Key and Bay grounds of Florida (pl. LIV) and in the Bahamas. Those from the Bay ground are very poor and are rarely brought in by the spongers, to whom they are known as "bread sponges," on account of their excessive tenderness. Glove sponges are very soft and elastic, but owing to the weakness of their fiber and their open texture they are almost worthless for commercial purposes. Hyatt states that "this is one of the grass sponges;" hence his name for it, but it is now generally known by the name used here.

The best glove sponges come from Biscayne Bay, where they grow stronger, less open, and with lower ridges than in other parts of the Keys.

REEF SPONGES.

The few reef sponges taken on the Key grounds in Florida are generally included with the yellow sponges and do not reach the market as a distinct sort. Those found in the trade come from the Bahamas, the north coast of Cuba, and British Honduras, the former two localities producing sponges of essentially the same character, while those from Honduras are inferior, more irregular and open, and with other indications of shoal water origin. Reef sponges are also taken on the west coast of Haiti.

Most reef sponges appear to belong to Lendenfeld's species *Euspongia officinalis rotunda*, embracing many of Hyatt's numerous varieties of *Spongia*

agaricina and *S. officinalis*. As might be expected from this statement, they are of varied shape, but comparatively uniform in quality and the appearance of the surface, which is a fairly even network inclosing numerous small round holes averaging about $\frac{1}{16}$ inch in diameter, the interlying ridges being covered with short, bristle-like bundles of fibers. In the general appearance of the surface these sponges resemble the finer grades of Mediterranean sponges much more closely than do any of the other American sponges, but the pores are somewhat larger and the projecting bundles of fibers are stouter and stiffer. In some specimens, particularly the helmet-shaped ones, which are apparently Hyatt's variety *disciformis*, the surface is softer than that of the zimocca, but not equal to that of the Mediterranean toilet sponge.

Most of the larger reef sponges from both the Bahamas and Cuba belong to Hyatt's *Spongia officinalis* subsp. *tubulifera* vars. *pertusa* and *mollis* (pl. LV), not Lendenfeld's *Euspongia irregularis pertusa*, and are massive lobular forms with the vents at the conical summits of the fistular lobes or the solid masses into which they fuse. In the furrows between the lobes and the depressions between the summits of those which have fused basally, the surface orifices are larger than elsewhere and the projecting bristles are much longer. The vents are generally arranged in more or less radiating rows extending down the sides of the sponge. Another common type is flattened in a vertical plane, with the oscula lying in a sharp crest extending longitudinally up the ends and across the top and surrounded by soft tufts of fiber longer than on the rest of the surface (pl. LVI). Between these two types there are intergradations tending to produce more or less massive forms, with the oscula in rows or scattered on rounded eminences. Others evidently belonging to Hyatt's *S. agaricina punctata* are considerably higher than broad, and have the oscula more or less radially arranged, those on the sides being slit in the direction of the base. These are often included among the "hardheads." The reef sponges are low priced and are used as desk sponges, for surgical purposes, for infant toilet sponges, especially when bleached, and for various purposes in the arts which require a soft sponge of no great durability.

HARDHEAD SPONGES.

The hardheads (pl. LVII), most of which come from the Bahamas, British Honduras, Haiti, and the north coast of Cuba, are another miscellaneous group, some of which are indifferently assigned to this or the preceding grade, as they are harder or softer to the touch. The hardheads are generally elastic and resilient, but somewhat less compressible than the preceding and harsher to the touch. They are also on the whole more regular in form.

A considerable number of them, especially among the Cuba specimens, belong to Lendenfeld's *Euspongia irregularis pertusa*, the larger and softer

specimens of which are classed as yellow sponges. Most of the others can be assigned to one or the other of Hyatt's varieties which Lendenfeld includes in his *Euspongia officinalis rotunda*. Common among these are conical or club-shaped forms sometimes bluntly branched (Hyatt's *agaricina corlosia* var. *elongata*) or rounded specimens attached by a narrow base (Hyatt's *officinalis tubilifera* var. *rotunda*). In both of these the surface is composed of narrow ridges separating small circular apertures and covered with short bristles. The larger of these sponges tend to become conical and somewhat flattened in a vertical plane, and they are also usually softer and more compressible than the smaller individuals. The oscula are large and conspicuous, they usually lie on more or less prominent rounded eminences and at the summits of the blunt branches, and tend to become slit-shape or elongate, especially on the sides. The hardhead sponges are used for applying shoe dressings, as desk sponges and for various purposes in the arts not requiring great softness. They are in general more durable than reef sponges.

WIRE SPONGES.

The wire sponge (pl. LVIII and LIX), sometimes called "bastard sheepswool," somewhat resembles the wool sponge in superficial appearance, though it more closely simulates the honeycomb sponge of the Mediterranean. In shape it is regular, rather broader than high, and attached by a broad base. The sides are perforated by numerous circular or polygonal orifices, separated by thin-edged partitions which, while sometimes ending in bristly tufts, are never prolonged into the long, soft, expanded processes characteristic of the sheepswool sponge, the surface of the wire sponge therefore lying in a more uniform plane. The oscula or "eyes" are confined to the upper surface, are smaller and more numerous than in the sheepswool sponge, and are rarely or never situated on the summits of cones rising above the general surface.

The wire sponge differs from the honeycomb sponge in its more open surface and general texture, its more bristly appearance, its much thicker fibers, and coarser, more open felt. If the fibers are examined under a lens they will be found heavily charged with sand granules, which impart to the sponge its characteristically harsh feel.

Until very recently wire sponges were rarely brought to market on account of their numerous bad qualities—their harshness, their lack of strength and absorptiveness, and the readiness with which they drain after being wet. Within the last year, however, a considerable demand has arisen, and they now yield the spongers a price per bunch about on a par with that of yellow sponges. They are all exported, and there is good reason to believe that they are bleached and sold as Mediterranean honeycomb. They come almost entirely from the west coast of Florida.

TURKEY CUP SPONGES.

These sponges (pl. LX and LXI, fig. 1), known also as fine Levant or fine Syrian, are the *Euspongia officinalis mollissima* of Schulze. They are sometimes massive, when they are known to the trade as "Turkey solids," but are frequently more or less cup-shaped, though perfect cups are comparatively rare, and as they are regarded as especially desirable bring high prices. The oscula are comparatively large and numerous and are grouped closely together on the upper surface of the solids or in the concavity of the cups, the skeletal partitions which separate them being often very thin. The outer surfaces are perforated by numerous round or polygonal pores, the narrow partitions between which are beset with long, slender, and very soft, fibrous pencils. The foreign bodies in the fibers are small in quantity, the main fibers themselves are comparatively few, and the microscopic network has rather large irregular and elongate meshes, this combination of characters making it the finest and softest sponge and one of the most elastic on the market.

The "Turkey cup" and "Turkey solid" are confined mainly to the eastern Mediterranean, though a closely related form comes from Zarzis, on the Tunisian coast. The very finest are obtained on the Syrian coast, but excellent qualities are found at Crete, Cyprus, and Mandruka in Egypt. It is stated that many of the best now come from caves and crevices, where they attain a finer and denser growth than elsewhere. This kind of sponge, like the Turkey toilet sponges, never attains a size comparable with that reached by most other commercial sponges, but the high price it brings compensates for its smallness. It is stated that a few of the very best sell for about $50 per pound. They are used mainly for the more exquisite purposes of the toilet.

TURKEY TOILET SPONGES.

These sponges (pl. LXI, fig. 2, and LXII) are mainly included in the zoological variety *Euspongia officinalis adriatica* of Schulze, though apparently some inferior specimens of the Turkey cup sponge are also embraced in this commercial species. Toilet sponges are flatter and more encrusting in their habit than are the cup sponges, and are generally broadly attached, though sometimes the base is constricted. The oscula are confined to the upper surface, being usually distributed over all parts excepting toward the edge, but in what appear to be compound individuals they are often arranged in groups. Each oscule is generally surrounded by a rampart of bristles. The surfaces other than those bearing the oscula are perforated by numerous fine pores. The ridges forming the network between these pores are rather sharp edged as compared with the cup sponges, while the fibrous processes which they bear are shorter, stouter, harsher, and more bristle-like. The sponge as a whole is less compressible than the cup sponges and not so soft and fine.

Toilet sponges are rather generally distributed in the Mediterranean from the Adriatic and the coast of Tunis eastward. They are used for toilet purposes, in surgery, and for leather dressing, pottery making, and various other purposes of the arts.

A somewhat similar sponge is found in great abundance at Sitanki, Philippine Islands. (Pl. LXIII.) Its general texture closely resembles the toilet sponge, but its upper surface bears longer tufts of fibers and numerous uniformly distributed oscula or pores about one-eighth inch in diameter, characters which cause it to resemble in that respect some of the grass sponges from the Florida Keys. It is very soft, but much weaker than the toilet sponge and about as strong as Key grass.[a]

ZIMOCCA SPONGES.

These sponges (*Euspongia zimocca*) are massive, more or less conical, broader than high, sometimes flat on top, sometimes concave, occasionally cup-shaped, and usually attached by a rather small base. (Pl. LXIV.) The oscula are scattered over the upper surface, occasionally arranged in irregular radial rows, and are frequently, though by no means always, surrounded by ramparts of bristly fibers. The whole outer surface consists of a reticulation of narrow ridges, inclosing numerous small pores and bearing short fibrous villosities which generally become longer and softer toward the upper surface. The surface texture of the skeleton resembles that of some of the Cuban and Nassau hardhead sponges, but the orifices are smaller, the intervening ridges are narrower, and the skeleton softer and more durable.

The zimocca sponge is found commercially in the Adriatic, the Dardanelles, on the west coast of Asia Minor, the coasts of Egypt, Tripoli, and Tunis, the islands of the Grecian Archipelago, Crete, Cyprus, Corsica, and Lampedusa. The zimocca sponges are the harshest of the Mediterranean grades, but in common with other kinds they become softer when bleached, though they are less durable. Both bleached and unbleached they are darker in color. They are used for toilet purposes, and by potters, leather dressers, and other artisans. They are generally too harsh for surgical purposes.

Seale describes a sponge which on the advice of a New York dealer he calls a "Philippine zimocca." The specimen shown to me was of excellent quality and commercially valuable, but was certainly not a zimocca sponge.

HONEYCOMB, BATH, OR HORSE SPONGES.

These are the *Hippospongia equina elastica* of Lendenfeld and are classed by zoologists with the yellow sponge of the Florida Keys, from which it differs

[a] I have recently seen one of these, in a good state of preservation, which has been in daily use for bath purposes for two years.

in shape, texture, strength, and softness. (Pl. LXV.) It is a massive, cake-shaped sponge, attached by a broad base, always broader than high and never "pineapple-shaped" as its American relative frequently is. The surface is fairly uniform, with the lamellæ superficially expanded and often forming narrow reticular bridges across subsurface cavities. The surface is covered with small rather blunt tufts or pencils of fiber, particularly around the edges of the numerous polygonal, circular, or meandering openings. The oscula are scattered over the upper part of the sponge, usually opening on the general surface, but occasionally surrounded by a rampart of fibers which produce a very short oscular tube. The general superficial aspect of this sponge is intermediate between the sheepswool and the velvet, being much less shaggy than the former and rougher and less meandriform than the latter. In surface appearance it somewhat resembles the Florida wire sponge. Certain sheepswool sponges which the author has artificially grown from cuttings in the Florida Keys reproduce quite accurately the surface texture of the honeycomb sponge.

The honeycomb sponge is quite generally distributed throughout the Mediterranean, being found from the Gulf of Lyons along the north, east, and south shores as far as the Algerian coast. It is known commercially from the vicinity of Marseilles, Corsica, the Adriatic, the Archipelago, the coasts of Asia Minor, Egypt, Tripoli and Tunis, Crete, Cyprus, Lampedusa, the Dardanelles and the Red Sea. The best are the Mandruka sponges, which are compact, soft, and fine, but those from Tunis, Crete and Asia Minor are little inferior and many of them enter the markets as Mandrukas. The Tripolitan honeycomb sponges are rough, coarse, and loose in texture, and those from the Archipelago are but little better.

As has been before stated, one of the yellow sponges of American waters is considered zoologically identical with the honeycomb, and the variety is also known from Australia and New Zealand, those I have seen from the former locality being harsh, open, coarse, and decidedly inferior to any known commercially.

As compared with American sponges, the Mandruka is softer than any except the Matecumbe sheepswool, but it is less durable than the Rock Island sheepswool, less resilient, and more quickly loses its elasticity in use. It is a popular bath sponge, for which its size and shape makes it excellent, but is being displaced in the American markets by the more generally superior sheepswool. These sponges are also used in the arts, by jewelers and silversmiths, leather manufacturers, and as desk sponges for bank tellers, etc.

ELEPHANT-EAR SPONGES.

These are the *Euspongia officinalis lamella* of Schulze and are either cup-shaped or cap-shaped with rather thin walls of uniform thickness or a more or

less rolled ear-shaped or fan-shaped plate from ½ to 1 inch thick. (Pl. LXVI.) The oscula are confined to the inside of the cupped forms or the concave faces of the lamellate specimens, and are arranged in groups of 4 to 6, surrounded by tufts of fibers longer than on the rest of the skeleton. These groups are generally in radial and concentric rows and the whole of the oscular surface of the skeleton often has more or less the appearance of being radially grooved, owing to the linear arrangement of the rows of fibrous tufts which cover it. The outer or convex surface of the sponge is more uniformly covered with soft fibrous tufts, though these tend to radial arrangement near the rim, and there are sometimes radial ridges or thickenings of irregular length extending from the base toward the margin. This sponge is very fine, soft, and durable, being equal in those respects to the Turkey toilet sponge. It is used for fine toilet purposes, for which its shape makes it desirable; for surgical purposes, and in the medical application of electricity, by potters, fine leather workers, jewelers, cane makers, hatters, and other artisans requiring a smooth, fine, soft, and durable sponge.

It is found commercially on the coasts of Provence and Dalmatia, in the Greek archipelago, on the coasts of Egypt, Tunis, and Algeria, and about the Balearic and Lampedosa islands, and the variety is known zoologically from the north coast of Australia.

A similar but much denser and harsher sponge is found near Jolo, Philippine Islands. In the few specimens that I have seen the fibers are heavily laden with sand grains, which makes them useless commercially, but it is possible that better grades may be found.

IV. THE FLORIDA SPONGE FISHERY.

The Florida Keys first received permanent settlement about the time that the present State was erected into a Territory upon its cession to the United States in 1821. Key West, the first and for many years the sole center of the sponge industry, was settled in 1822, and it is probable that the early inhabitants soon learned, from the specimens thrown up on the beaches of the keys, of the presence of several species of useful sponges in the surrounding waters. It is known that long before these became an article of commerce they were in limited domestic use among the inhabitants, but it was apparently not until 1849 that they were given a commercial value. In that year a cargo of sponges was sent to New York on a venture, probably as the result of knowledge of the recently discovered commercial value of the sponges in the Bahamas, which islands furnished the majority of the early settlers of Key West and have since maintained with it close social relations. Before this time the entire sponge supply of the United States was derived from the Mediterranean, though of later years a few sponges may have come from the Bahamas, which had begun to export seven or eight years

before, but that the supply from the latter source must at most have been small is shown by the fact that its total exports to all countries in the year mentioned were valued at but some $10,000. In any event, sponges other than those from the Mediterranean were but little known and the venturesome cargo from Key West narrowly escaped being thrown away as worthless. Its ultimate sale, however, established a market for this newly discovered product of the keys, and several merchants at Key West began to buy the better grades and to take them in trade. It is said that at first the price was but 10 cents per pound, presumably for sheepswool sponges, but as the quality of the domestic product became better known the price improved, there began to be a systematic investment of capital to take the place of the desultory fishery previously carried on, and a class of men developed whose principal or sole business and means of livelihood was gathering sponges.

THE SPONGING GROUNDS.

The sponging grounds as at present developed are broadly divided into two widely separated areas, the "Bay Grounds," lying in the open waters of the Gulf of Mexico, from about Johns Pass to St. Marks, and the "Key Grounds," stretching along and among the reefs and keys from Cape Florida to Boca Grande Key.

That there is sponge-bearing bottom between the New Ground off Cape Sable and the mouth of Tampa Bay admits of little doubt, but notwithstanding that the Key West fleet has traversed that region year after year in going to and from the Bay grounds, practically no sponges have been taken there, owing mainly to the depth and almost constant turbidity of the water. A few spongers have reported seeing sponges, but never in considerable quantities.

The grounds as exploited and worked by the hookers up to the time of the introduction of diving apparatus, in April, 1905, covered an area of 4,350 square miles, of which the Bay grounds contained about 3,400 and the Key grounds about 950 square miles. It must not be considered, however, that all of this area is productive, for on the contrary the actual sponge-producing bottom in any given field is far less than the barren areas with which it is mingled.

Sponges grow neither on sand nor mud, nor primarily on grassy areas, but must have some firm clean body to which to attach when the small free-swimming larva is ready to settle down and assume its final fixed condition and form. Among the Keys the bottom in the main consists of sand and more or less calcareous mud or marl, either naked or less frequently supporting a grassy growth, while on the Bay grounds it is generally sandy offshore with more or less grass in the shallow waters close to land. In the channels and other places among the keys where the currents run with sufficient velocity to scour the bottom or the waves prevent the excessive deposit of silt, the coral rock is exposed and furnishes

attachment for sponges and other sessile marine organisms. In the same way on the Bay grounds the bottom is denuded by currents in the channels, as at the north end of Hog Island, and on the Buoy grounds above Anclote Key, while offshore there are rugged outcroppings of rock rising above the surrounding sand. It is upon these "spots of bar," as the spongers call them, insignificant in area as compared with the adjoining stretches of sand and mud, that the sponges occur in greatest abundance, attached to the rocky floor of the sea.

Occasionally they grow on sea feathers, which in turn are anchored to the bottom, or on mangroves, and considerable numbers are often found in the grass or in saucer-shaped sandy depressions surrounded by grass. Their occurrence in the latter places apparently contradicts the statement that they do not grow on grass or sand, but the contradiction is apparent rather than real, as they have been in all cases originally attached, but either in the operation of sponging or by wave action have been torn loose, and rolling freely over the bottom at the mercy of the waves have finally been entrapped in the tangle of vegetable growth. Such sponges are generally almost spherical, have no "root," and the surface is uniformly smooth from friction on the bottom and harsh from the excessive inclusion of sand grains. They are known to the spongers as "rollers" or "rolling johnnies" and are often found in groups in sandy depressions in grassy bottom called "turtle sets" from the erroneous supposition that they are made by turtles.

BAY GROUNDS.

The Bay grounds, which formerly held a secondary place commercially, now yield practically the entire production of Florida sponges, the Key grounds furnishing hardly 9 per cent of the sheepswool sponges and less than 13 per cent of all kinds. The Bay grounds begin at or near Johns Pass, a few miles north of Tampa Bay, and extend without material interruption as far as St. Marks, a distance of 160 miles. As known at the time of the introduction of the diving machine, this ground extended from a depth of 10 or 15 feet to from 7 to 12 fathoms 20 to 40 miles from shore, but although sponges had been seen in the greater depths, no sponging had been done in more than 8 fathoms owing to the limitations imposed by the methods employed. Grass and a few sheepswool sponges were taken in less than 10 feet of water, especially in the early days of the fishery, but the bulk of the product was from between 20 and 35 to 40 feet, though in 1902, owing to unusually favorable conditions, a heavy catch of fine sponges was made in water as deep as 45 or 48 feet. Several persons had reported seeing sponges in 20 fathoms, and it is stated that on at least one occasion a sponge was brought up from 17 fathoms on a fish line.

In 1905 the area of the known sponge beds in the Bay grounds was about 3,400 square miles. Since then the operations of the divers, who in a few cases

have gone as deep as 110 feet, have slightly extended this area, and as that method of sponging becomes older and the shoaler waters more exhausted it can hardly be doubted that other productive grounds will be found in the greater depths. Should the Bay grounds be found to extend generally to a depth of 15 fathoms, about 3,700 square miles would be added to the area of sponge bottom, while if they prove productive to a depth of 20 fathoms there would be added to the area developed by the hookers no less than 5,900 square miles, making a total of about 9,300 square miles of sponge-producing bottom between Johns Pass and St. Marks inside of the 20-fathom curve.

It must of course be understood, as before intimated, that this area is not all productive. In general, the sponges are confined to the "barry bottom," which rises in patches like rocky islets above the sands that cover the general floor of the Gulf (pl. XXVIII). These bars are always more or less scattered, here isolated, there occurring in groups or series of ridges, and in the operations of sponging much time is consumed in looking for them. In the deeper waters they are found with the lead and in the shoaler waters by searching the bottom with the water glass or water telescope.

The bars, especially in the shoaler water, are sometimes moderately level expanses, but are generally rough and rugged, with fissures, clefts, crevices, miniature precipices and overhanging ledges, in all parts of which the sponges grow like lichens clinging to the rocks, sometimes exposed to view from above, often hidden in semidark recesses on the sides of upright walls or beneath projecting ledges. They are mingled with noncommercial sponges of many species, with gorgonians (sea feathers, etc.), polyzoa (sea moss), and corals, and surrounded by a wealth of life—fishes, mollusca, crabs, shrimps and other crustacea of bizarre shapes and brilliant hues, starfish and sea-urchins of varied form, sea cucumbers and worms, some permanently attached to the rocks and others free to wander, yet finding on the bars rich feeding grounds, oases in the vast desert of sand lying round about.

Compared with the total area of the sponge grounds the extent of these bars is small, nobody can say how small relatively, but it is from them and practically from them alone, that the supply of sponges must be drawn. Their distribution is irregular in different sections of the grounds and in different depths; sometimes there are great areas of white sandy bottom quite devoid of rocks and again the bars are comparatively closely approximated over a wide range.

The Bay grounds are broadly subdivided by the spongers into the Rock Island, Pepperfish, New, St. Martins Reef, Anclote, and Highland regions, each in itself of uncertain boundaries and more or less subdivided into indefinite sub-localities. The names used by the spongers are very contradictory, and the location of a fleet working in a given area may be described in five or six different

ways by hardly more than that number of masters. The reasons for this are twofold. In the first place the local distinctions between the grounds are purely artificial, as the sponge-bearing belt is practically continuous, bearing in mind the irregular distribution of the bars themselves, and in the second place the spongers when out of sight of land do not know exactly where they are, few if any being navigators. They usually refer their location to their last point of departure and it may thus happen that of two vessels working side by side one will declare itself off Rock Island and the other off Pepperfish Keys, the two locations being over 40 miles apart, the first vessel having sailed south and the other west from the last landfall.

Though the grounds as at present known to the spongers are indeterminate as to their boundaries, there were originally apparently natural distinctions between some of them. The shoal-water areas were first discovered and worked and there it was found that the sponge-bearing bottom was interrupted by large areas of smooth barren sand and grass. One of these, lying off Piney Point, separates the inshore parts of the Rock Island and Pepperfish grounds, and another and larger one, extending for 30 miles opposite Cedar Keys and the mouth of the Suwanee River, lies between the Pepperfish and St. Martins Reef beds. Each of these extends to a distance of 20 to 25 miles from shore and to a depth of 5 to 8 fathoms. Later discoveries developed bars outside of these "lakes" as they are called, so that in the deeper water the grounds are now continuous.

The most prolific beds extend from off Cedar Keys to the waters southwest of Anclote, including New, St. Martins Reef, and Anclote grounds. About 1895 the sponges on the Rock Island, Pepperfish, and New grounds were killed off by "poison water," which extended from the vicinity of St. Marks to the beds off the Suwanee River. Recuperation of the beds first began to make itself evident about 1901.

Rock Island region.—The region so designated takes its name from a small island about 22 miles to the eastward of St. Marks light. It extends from about Ocklockonee shoal to the smooth sandy bottom off Piney Point, which separates it in its shoaler parts from the Pepperfish Key beds. As developed by the hookers, it had an area of about 800 square miles, about 50 miles of which, forming a strip a few miles offshore, yields grass sponges in considerable numbers. Inside of the 5-fathom line the Rock Island beds produce sheepswool sponges in great abundance, though most of them are comparatively small. When first discovered, the sponges were larger; but owing to the intense fishery in the shoal waters they now have no opportunity to grow, if, indeed, their size has not become permanently impaired by the persistent and constant selection out of the larger ones, as appears to be the case at Sugar Loaf Key also.

The sheepswool sponges of this region are of fine quality, close and tough of fiber, rather flat or cake shaped, and somewhat darker in color than the Key sponges. They bring a higher price than any American sponges, though probably not superior to those from other sections of the Bay grounds, the product of all of which goes under the general designation of "Rock Island."

Pepperfish Key region.—These beds lie opposite Pepperfish Keys and extend from the sandy bottom off Piney Point and Grass Island to the similar, though larger, area off the Suwanee and Cedar Keys. In the deeper water they join the Rock Island beds on the one hand and the New ground beds on the other. They lie in a depth of from 6 to 7 feet to 10 or 11 fathoms, beginning about 3 or 5 miles from shore, and extend a distance of about 25 to 35 miles. Their total area in 1905 was about 550 square miles, of which about 75 square miles, lying in a depth of from 8 to 18 feet, was mainly productive of grass sponges.

New Ground region.—The New ground is so called because it was discovered at a later period than those on each side, Pepperfish and St. Martins Reef, between which it formed a connecting link in the deeper water outside of the sandy area, which separates them shoreward. Its extent northwest and southeast is about 30 miles, lying in sinuous outline in a depth of between 5 and 10 fathoms at the stage of development of 1905. Its width varies, but averages a little over 10 miles, and its area as exploited by the hookers is about 350 square miles. This is a prolific ground and, in the opinion of the hookers, marks the northern limit at which the sponges are at present most abundant.

Withlacoochee Bight and St. Martins Reef.—This includes the sponge beds between the mouth of the Waccasassa River and Sea Horse Reef on the north and St. Martins Reef on the south, covering an area of about 1,100 square miles. As developed by the hookers, the beds ranged from a depth of about 7 or 8 feet to 9 or 10 fathoms; but the divers have since found the productive bottom to extend in some places to 15 or 18 fathoms.

Withlacoochee Bight is prolific in sheepswool sponges, but owing, perhaps, to the discharge of the numerous small streams along shore the water is generally too cloudy for the hookers to work to advantage. In the shoaler water, from 1 to 3 fathoms deep, extending along the inner edge of these grounds for almost their entire length, there is an area on which grass sponges predominate, and some years ago many fine large ones were taken there; but it is stated that the growth now consists almost wholly of small specimens. In the deeper water sheepswool and yellow sponges predominate, with a considerable number of large grass sponges. This region and the grounds to the southward are those now principally resorted to by the divers.

Anclote region.—The Anclote region, practically continuous with the preceding and the following, extends from St. Martins Reef to about Big Pass,

and as known in 1905 covered an area of about 290 square miles. At that time the depth in which the sponges were found extended from about 4 or 5 fathoms to about 8 to 10 fathoms; but the divers have since then taken large quantities in from 10 to 15 fathoms, and a few boats are said to have worked as deep as 18 fathoms. There are a few small patches of bar in waters as shoal as 2 or 3 fathoms on the Buoy grounds, in the channel south of Anclote Key and near the north end of Hog Island. The Buoy grounds are noted for their rapid recuperation. The deeper waters produce a fine grade of sheepswool sponges, and both yellow and grass are also found in considerable quantities.

Highlands region.—This, the southern limit of the Bay grounds, stretches from Big Pass to Johns Pass, the known distribution of sponges in 1905 covering an area of about 300 square miles. Owing to the absence of streams discharging fresh water, the sponges extend much closer to shore than in the regions to the northward, but they range offshore to about the same depths as in the Anclote region, though, owing to the steeper slope of the bottom, the hookers never worked so far from shore.

KEY GROUNDS.

The Key grounds, though for many years the only source of supply of Florida sponges, are now comparatively exhausted and of reduced value. During the past few years they have produced about 30,000 pounds of sheepswool sponges per annum, while in 1900, an exceptionally good year for these grounds, the catch was 58,294 pounds. The production of all kinds averaged 79,487 pounds in the years 1906, 1907, and 1908, while in 1899 and 1900 the average was 139,458 pounds.

Between the keys and the mainland the grounds extend from Boca Grande Key and Cape Sable as far as the Cowpens, off Long Island, and from the lower end of Cards Sound to Cape Florida. In Hawk Channel there are patches of sponge-bearing bottom along the line of reefs forming its outer margin, and at intervals close to the keys which define it on the landward side, from near Key West as far as Hillsboro Inlet; but, though at one time fished throughout the entire distance, it is only between Knights Key Channel and Soldier Key that these patches now attract the attention of spongers.

The interruption in the distribution of sponges inside the line of keys from Long Island to Cards Sound, mentioned above, is due to the low salinity of the water. For nearly 30 miles Key Largo imposes an unbroken barrier against the interchange of waters between the inside bay and Hawk Channel, with the result that the drainage of the Everglades is impounded and the salinity reduced below the degree which inhibits sponge growth. On two occasions I have run a line of salinity observations through this barren area

and found the density gradually falling from about 1.0205 on the sponge grounds at either end to about 1.0135 approximately midway between. All other conditions for the maintenance of sponge life appear to be present, and certain species, like the loggerhead, more tolerant of fresh water, are found in abundance. In the construction of the new line of railroad to Key West many of the passes between the keys west of Key Largo have been completely or partially closed and it is not improbable that the salinity of the water will be so lowered as to affect adversely the sponge grounds near the Matecumbes.

The Key grounds produce sponges in greater variety than the Bay grounds. Not only are there more noncommercial species but there are more useful kinds, and of each of these there are a number of local varieties readily recognized by the spongers and dealers. All have, however, one well-marked characteristic that in general serves to distinguish them from corresponding species taken "up the bay," namely, a reddish or rusty appearance of the interior fibers, called "red root" on account of its being more readily seen on that portion of the sponge torn away from its attachment to the bottom. This color is not generally exhibited by the strictly peripheral fibers, but is readily observable in the oscula and at the bottoms of the channels or grooves which traverse the surface, and upon cutting the sponge it is found to permeate the whole interior. It is due to an oxide of iron and is popularly supposed among those engaged in the business to be caused in some manner by the coral rocks to which the key sponges are commonly attached. That it is due to the constituency of the water among the keys there can be no doubt, but that it is not absorbed directly from the rocks is shown by its presence in sponges growing above the bottom attached to sea feathers (gorgonians) or artificially grown from cuttings attached to suspended wires. Red-rooted sponges are almost invariably more tender, weaker in fiber, and less durable than those of generally similar texture not so colored, but whether the coloring material causes the weakness or whether the conditions producing the two are merely coincident can not be stated. The color is quite different from the paler yellow seen in some of the Bay sponges.

The "barry bottom" of the Key grounds is generally fairly level as to surface, though on the reefs and in places on the Key shore of the Hawk Channel there are bowlders and heads of coral rock, often rising from a depth of 2 or 3 fathoms almost or quite to the surface. The commercial species found on the Key grounds are sheepswool, yellow, velvet or boat, grass, and glove. The velvet or boat sponge is obtained principally from the reefs and owing to the difficulty of working in that exposed region is to be had in but comparatively small quantities. The other species are generally distributed.

The Key grounds are subdivided into innumerable more or less poorly defined areas, each of which has received from the spongers one or more local

names, sometimes fanciful, but frequently having some topographic, personal, or historic origin. It is impossible to describe within reasonable limits all of these various sublocalities, but a few of the more important will be mentioned.

The New grounds extend from Cape Sable and Middle Cape southwest to beyond Contents Keys and westerly from a depth of 11 feet to a depth of about 5 fathoms. The bottom consists of a series of more or less extensive bars separated by white sand, and the sponges produced are of excellent quality, generally pineapple-shaped and colored less brightly red than is usual in the keys. All classes of sponges are found, but the water is rarely clear and the grounds are therefore but occasionally productive. Southeast of this are "spots of bar" stretching to the so-called lakes along the line of keys as far as Lower Matecumbe.

West of Key West there is an area lying between Boca Grande, Man, Woman, and Mullet keys and the slope of Lavinia Bank, where most of the sponges are rollers. There are also beds along the sides of Northwest Channel, one of the entrances to Key West Harbor.

Between Key West and Bahia Honda.—In this region sponging has been carried on for many years in Wall Key Lake, Johnson Key Lake, Sugar Loaf Sounds, and in all of the long narrow channels leading between the keys. In the lakes and sounds schools of fish and in the channels the strong currents keep the water muddy a large part of the time. Sheepswool, yellow, grass, and glove sponges are found, but the quality of the first two is inferior.

Money Key and Pigeon Key lakes.—These areas are practically continuous and lie between Bahia Honda and Knights Key Channel, extending north and northwest to Teakettle and East Bahia Honda keys. The water has a maximum depth of about 9 or 10 feet in the former and 11 or 12 feet in the latter. Wool, yellow, grass, and glove sponges are found, the former being superior in quality to those found to the westward.

Knights Key Channel, Rachel Key Lake, Grassy Key Lake, and Channel Key Lake.—These form a practically continuous sponging ground between Knights Key and the sand banks and shoals running northwest from Long Key, and in the palmy days of the key fishery were much resorted to by the Key West fleet. During recent years, in common with the rest of the key grounds, this area was nearly exhausted and comparatively deserted by spongers, but in the spring of 1908 and the following winter excellent sheepswool sponges of good shape, size, and quality were being taken in the vicinity of Bamboo Key. They were described by dealers as being of the highest quality of Key sponges and unusually free from the objectionable red color before mentioned, and the spongers stated that there was an abundant young growth on the grounds. This appears to be an evidence of the natural recuperation of the

sponge beds when, either by legal prohibition or from commercial considerations, they are wholly or partially abandoned for a few years. On most parts of this area the barry bottom is scattered and the water, which has a maximum depth of about 10 feet, is frequently too muddy for work.

Jewfish Bush lakes.—These, known respectively as the upper and lower lakes, stretch from Jewfish Bush and Lower Matecumbe Key northwest to Schooner Bank, and produce limited quantities of excellent Key sheepswool. The bars are scattered and of comparatively small extent, and, particularly in the upper lake, the sponge growth is mingled with sea feathers and many kinds of noncommercial sponges. The water varies in depth between 6 and 10 feet, the deeper water being toward the northwest.

In the summer of 1908 the sponge beds in this region and to the eastward were destroyed by "poison water." It is probable that this was fresh water from the Everglades, impounded by the railroad embankments of the "Key West Extension." The closure or partial closure of the several channels between the keys must result in the westward extension of the same density conditions which formerly prevented the growth of sponges inside of Key Largo, to which reference has been made before.

Lignum-Vitæ and Cotton Key lakes.—These lie north of the Matecumbes and Lignum-Vitæ Key, are connected by Ironwood Channel, and almost surrounded by sand banks. The bottom of the former is almost all hard, and bears a scattered growth of sheepswool sponges and considerable quantities of other species. In Cotton Key Lake the rocky bottom is scattered and the growth consists mainly of grass sponges. In Lignum-Vitæ Lake the depth is generally between 6 and 8 feet, while in Cotton Key Lake it averages about a foot less. The sheepswool and yellow sponges from these and the two lakes previously mentioned are the softest produced in Florida, making them especially desirable for bath purposes; they are known to the trade as "Matecumbe," wool and yellow.

The Cowpens are at the eastern limit of sponge growth inside the keys west of Cards Sound. They produce few sponges, and those found are usually rollers on the soft bottom.

Biscayne Bay.—Cards Sound, which lies west of Biscayne Bay, contains a few yellow and grass sponges and an occasional sheepswool, but has never been of importance. There are also a few grass and yellow sponges scattered over Cutters Bank, which lies between the two bodies of water.

Billies Lake, which lies in the southern part of Biscayne Bay between Cutter and Featherbed banks, contains a scattered growth of sheepswool, yellow, grass, and glove sponges, and it is stated that in that portion nearest Sands Key, which is at present the most productive, the growth was at one time prolific. It is probably now restricted by the number of small boats which

for years have resorted to the locality. Featherbed Bank Lake lies in the deeper water between Featherbed Bank, Ragged Keys, and Black Ledge. Small patches of bar scattered over this area in from 7 to 12 feet of water produce limited quantities of sheepswool and yellow sponges and large numbers of grass.

Soldier Key Lake comprises all of the remaining sponge-producing area of Biscayne Bay lying between Ragged Keys, Black Ledge, and Cape Florida Channel. Most of the sponges are found in the eastern part, near the extensive banks which separate the bay from Hawk Channel, but the work of sponging is much interrupted, owing to the general muddiness of the water. Formerly large quantities of sheepswool and especially grass sponges were taken here, but owing to overfishing their numbers are much reduced, though there is no doubt that they still exist in considerable quantities in those places which least frequently clear. The sponges of Biscayne Bay are generally loose, "frizzly," and inferior, and are therefore not highly valued in the markets.

Hawk Channel.—The westernmost bed frequented by the spongers lies off Pigeon Key. Sponges in commercial quantities are found off the Sisters, at Duck Key, Long Key, Lower Matecumbe, from Upper Matecumbe to Tavernier Creek, between Tavernier and Rodriguez keys, off Key Largo, between Key Largo and Old Rhodes Bank, at Old Rhodes Key and at Ragged Keys. North of here they extend as far as Hillsboro Inlet, where the reefs cease, but are now never fished. Sheepswool, yellow, glove, and grass sponges are taken on all of these beds. Velvet or boat sponges are found along the inside of the reefs from the vicinity of American Shoal to Fowey Rocks, and they are not known to occur in commercial quantities at any other place in Florida. As they are not particularly abundant or valuable and as the water in their habitat is generally rough, few of them are taken.

HOOKING.

At first the fishery was carried on by wading in the shoal waters in the immediate vicinity of Key West, especially to the eastward, the sponges being pulled by hand. Later the sponge hook was introduced, originally a two-tined sharp hook attached to a pole of moderate length, but latterly the number of tines was increased to three, the type now universally employed (text fig. 1). With the introduction of this implement slightly deeper waters were explored, the fisher standing in the bow of his boat closely scanning the bottom for sponges and tearing them loose with his hook as discovered. To calm the ripples which interfered with their vision the spongers soon learned to make use of oil, and that extracted from the livers of nurse sharks was found to be the best, as it forms a tenacious film and at the same time spreads over a wide area of water. Thin, light oils are ineffective, as they are speedily dissipated and fail to quell the ripples in even a gentle breeze. The oil is usually carried in a wide-mouthed

bottle and is sprinkled on the water in small quantities by means of a stick or swab, the sponger drifting with the "slick," poling back and forth so as to cover its entire breadth.

This method of sponging is still followed in the vicinity of Key West and among the keys where the depth does not exceed 5 or 6 feet, two or three men, each with a dingey, cruising about on little sloops, cooking, sleeping, living, and to some extent curing their sponges in the most contracted of quarters. They usually build small, frail "crawls" of a temporary character, to which they return each night while in the vicinity, or else the whole product of the trip is carried back to Key West, often in a most unsavory condition, and "crawled" at that place. This fishery is now generally followed only during the winter months, when the more profitable deep-water fisheries can not be prosecuted on account of the weather, or at other seasons of the year by the less skilled spongers, by persons temporarily out of other employment, or by the local residents of the keys. It is prosecuted mainly on the Key grounds as far as the Cowpens and its product is small.

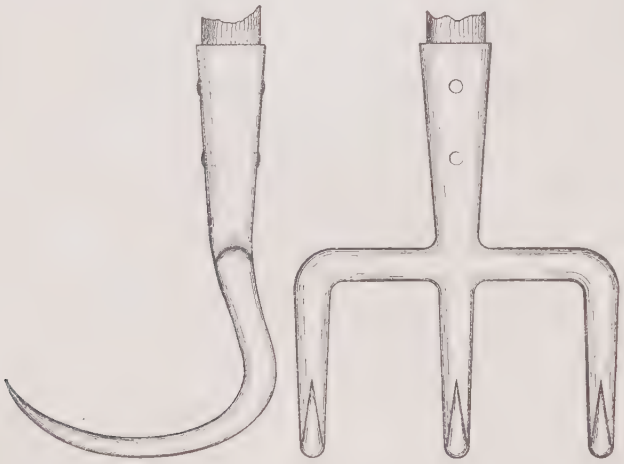

FIG. 1.—Hook used by the sponge fishermen of Florida.

With the growth of the demand for sponges and the depletion of the beds nearer Key West, the search for other grounds carried boats farther and farther away until the Matecumbes were reached. Here it was found that the sponge growth inside the keys came to a more or less abrupt limit, but along the northwest shore of Hawk Channel, between the keys and the reefs, the workable beds were found to extend as far as Norris Cut, a few miles north of Cape Florida. In 1879 this appears to have been the known extent of the Key grounds, as is shown by a chart of about that date prepared during the canvass for the Tenth Census. Few inhabitants then lived on the shores of Biscayne Bay and the beds in the waters within that bay and Cards Sound, if known, were rarely if ever worked, although soon after that time they were extensively resorted to by the Key West fleet, which found sheepswool sponges of rather inferior quality and especially grass sponges in large quantities. The sponge grounds were also found to extend along the reefs as far as Hillsboro Inlet, but owing to the prevalence of heavy seas on this part of the coast they were not extensively exploited.

With the extension of the fishery into the deeper waters of the channels and some of the "lakes," as the spongers term the broader expanses between and behind the keys, the old method of sponging became inadequate. Poling became laborious if not impossible, and, moreover, a man standing upright in the boat was unable to see the bottom with sufficient distinctness. To overcome this difficulty the "sponge glass" or "water telescope" was introduced, at first a square wooden box or tube with a pane of glass in one end, but afterwards an ordinary wooden pail with a glass bottom substituted for the wood. The device is said to have been employed first about 1870 or a little before, and correlated with its use came other changes. It was now necessary to have two men in the boat, one to propel it and the other to search for and take the sponges. The skiffs and miscellaneous small boats previously employed were displaced by the present type of dingeys, yawls about 14 or 15 feet long and about 4½ feet beam, light, strong, and handy, with a sculling notch at the stern. The latter is an oak board notched at the top, sometimes fixed but frequently sliding between guide pieces so as to be removable when the boats are hauled aboard the vessel.

Large vessels also came into use, especially after the development of the fishery on the Bay grounds, where the work is carried on often at a distance of 20 to 30 miles from shore. The smaller vessels, many of them under 5 tons, are employed among the keys where shelter in case of bad weather is usually close at hand. The registered vessels range from 5 to about 50 tons, most of them being under 15 tons measurement. The majority are rigged as schooners, but many of the smaller ones are sloops, as are practically all of the boats measuring less than 5 tons employed in the fishery among the Keys. Practically all of the boats and most of the vessels have been built at Key West, but some, especially the larger ones, have come from other places.

In the boat fishery from one to five men constitute the crew, the usual number being about three. A man working by himself must confine his operations to poling in shoal and smooth water, but two or more men, if occasion demands, may work in rougher and deeper water by using the water glass. The vessels carry crews of from 5 to 13 men, according to size, the usual number being about 7 or 9, the captains even of larger vessels objecting to crews of more than 11 on account of the difficulty of controlling the men. The number is usually odd on account of the distribution of duties as hereafter explained. As a rule the best men get together, as the proceeds of the trip go into a common fund from which each man receives his share according to his duties, and the presence of an unskilled or lazy man in the crew lessens the catch of the vessel and consequently reduces the profits of his fellows.

When a vessel reaches the sponging grounds, if the weather be favorable and the water sufficiently clear, a bar is located by means of the lead or by

"sighting" with the water glass, and the crew is sent out in the dingeys, two men in each, while the odd man, usually the cook, handles the vessel under shortened sail and picks up the boats at noon and night, or when signal is made by hoisting an oar blade up.

The men in a boat are called, respectively, the sculler and the hooker, the duty of the former being to propel the boat in obedience to the signals of the latter and to assist in handling the hooks when necessary. A proficient sculler has great command of the boat, stopping it almost on the instant, backing, going ahead, or making it spin as if on a pivot, as the exigencies of the work require. He will keep at work with easy grace all day long, and much of the success of the boat depends upon his skill and willingness. Upon the hooker devolves the work of finding and catching the sponges. His station is in the waist of the dingey, where he kneels, leaning over the side, watching the bottom through the water glass, the hook, with its pole, resting conveniently at hand across the gunwales, where it may be seized upon the instant. The position is a trying one physically, especially when the sea is choppy, and when the waves grow rough the work is impossible. The sponge glass, or bucket with its glass bottom below the surface of the water, operates by dispelling reflections, and to heighten its efficiency the hooker usually wears a large "conch" straw hat, which cuts off a large part of the direct light when his head is thrust well into the mouth of the bucket. By this means the bottom may be seen more or less plainly in clear water to depths of 50 feet.

When a sponge is sighted the sculler, at a word or signal, maneuvers the boat into position, the hooker seizes his hook, rests the pole on his shoulder as a fulcrum and with his right hand lowers it and inserts the tines into the base of the sponge, more or less plainly seen through the water glass held in position with the left hand. In pulling or tearing the sponges from their attachment considerable care and skill is required to prevent mutilation, which, of course, impairs their value in the markets. They sometimes adhere so tightly that it requires the united efforts of both men to loosen them, and in most cases more or less of the base of the sponge is left behind to grow anew under favorable conditions into a perfect specimen. From this cause, on bars which have been long worked, there are found many sponges of considerable diameter, but so low and flat that there is no room for the insertion of the hooks, and the hookers, much to their disgust, sometimes waste considerable time in futile efforts to detach them.

In deep water poles 50 feet long are sometimes employed, and as they bow and catch in the water if placed athwart the gunwales they are carried fore and aft, the hook over the bow and the other end trailing astern. In using these long, heavy poles the sculler always assists the hooker, placing the pole on the latter's shoulder and helping to handle it both in lowering and in

bringing it up. Even with this assistance the strain on the hooker is great, and in working in depths of 40 feet or more cases of hernia and similar injury are not infrequent even among strong men. The currents are often strong even when the sea appears calmest, and the slender, flexible poles bend and sway so that the greatest skill and strength are required to direct and insert the hooks. Should the current carry the hooks away from the sponge it is often impossible to force them back, and they have to be brought to the surface for a fresh effort.

Cloudy water brought from the swamps by the streams on adjacent shores, and milky water due to the stirring up of the sand and calcareous marls of the bottom, are the greatest impediments to this method of sponging, and the skill and experience of the hooker are largely exercised in seeing and recognizing the more valuable species under these adverse conditions. The tyro after very little practice can hook sponges in clear shallow water, but in depths of 15 feet when the water was somewhat roily I have seen one man catch eight times as many as another on the same bar, owing to his superior eyesight, the two men not differing greatly in the length of their experience as spongers.

In deep water—that is, in depths over 38 or 40 feet—probably not more than one-third of the hookers have sufficient strength, keenness of sight, and skill with the pole to work successfully. In consequence of this and the fact that only when the water is exceptionally clear can the sponges be seen at all in the greater depths, most of the hooking is carried on in less than 6 fathoms, and the inshore grounds have been the first, therefore, to become depleted. As a general rule the sheepswool sponge is now more abundant outside than inside the 6-fathom curve, and it is practically commercially extinct in the waters close to shore where it formerly abounded. Experienced captains, therefore, are in the habit of running offshore from time to time to "take a sight;" that is, to look for bottom with their water glasses, well knowing that if the water be clear and other conditions favorable, they can probably take more sponges in a day than they could in a week on the overworked inshore grounds. The spongers state that while the surface water may be clear the lower stratum is often turbid from the bottom materials stirred up by the swinging motion generally observed in the deeper waters of the Bay grounds.

If all the conditions be favorable, which is rare, the harvest is rich for those who can stand the arduous deep-water work. In the summer of 1903 an unusual condition prevailed in the deep water off the Rock Island region, where the water was clear and the weather favorable for a continuous period of many weeks. This gave the hookers access to bars in depths as great as 45 to 48 feet, which had rarely, if ever, been worked, and the result was a heavy catch of large, fine, perfect sponges of the best quality, which brought a good price in the markets. There has been no recurrence of this good fortune.

As is elsewhere described, sponges are not distributed uniformly over the bottom, but are found only on the scattered bars or rocky outcrops and coral growths. Sometimes a score or more will be found in an area of a few square feet, and again the same number may not grow on an acre of bottom apparently equally favorable for their attachment. Knowing this, the sponging boats will draw together when one is observed to be making a catch and it is not unusual to see dingeys so close to one another that the hookers can hardly wield their poles without collision.

In recent years, where the sponges are much scattered, or the bars small and irregularly distributed, the methods of hooking just described have been somewhat modified to meet the conditions. Instead of the sculling of the dingeys, these are towed by the vessel under shortened sail, sometimes as many as four, two astern and one on each side, from booms rigged well out forward. The hookers crouch in the sterns of the dingeys, scanning the bottom through their glasses, and when a sponge is seen a small buoy with a cord and anchor weight is dropped to mark the spot, the painter is cast off from the vessel, and the sponge is taken in the manner already described. Much larger areas can be systematically covered by this means than by sculling, and regions may be fished with some profit where the sponges have become too few and scattered for the usual methods to yield results.

In the Key grounds the vessels usually anchor at night close to the sponging grounds, and in fair weather some of the larger vessels do the same on the Bay grounds; but the greater number run inshore at night and out in the morning, thus losing much valuable time, especially when the morning winds are light and the conditions are best for work.

The crews are paid on shares, the distribution of the proceeds of a trip being usually as follows: The "vessel" furnishes boats, apparatus, and food, and in return receives one-half of the product of the trip. The other half is distributed so that the hookers get one and one-fourth share and the captain, scullers, and cook one share each. The captain in addition draws 10 per cent of the vessel's portion and each member of the crew is usually assessed a small sum for the payment of the watchman at the crawls.

The sponging industry of the United States was virtually introduced from the Bahamas, and so far as the spongers themselves are concerned, the fishery remained largely in the hands of the natives of those islands until the introduction of diving. In 1900, according to Cobb, of the 2,113 persons engaged in sponging, 1,268, or 60 per cent, were born in the British provinces, and of these 1,013 (80 per cent) were negroes. Of the 839 American-born spongers, 343 (41 per cent) were colored. Taken as a whole, of the persons engaged in hooking, about 65 per cent were negroes. Until 1906 neither the numbers

nor the proportions above stated underwent material change, but at the present time (1909) the number of persons engaged in hooking is considerably less on account of competition of the divers, though the proportional national and racial representation appears to be about the same. As a class, these men are industrious workers when actually on the grounds, but after their weekly trips to the crawls it is often difficult to get them promptly aboard the vessels again. The system of making advances against their shares of the catch also operated against their efficiency, as some crews, when a period of "bad luck" made it apparent that at best their earnings would hardly more than suffice to pay their indebtedness, would lose all interest in the work and spend their time largely in idleness or the most desultory labor. Some crews also frequently exchanged considerable parts of their stores for intoxicants brought by Cuban fishing smacks operating off the coast, either drinking the proceeds of the bargain or smuggling it ashore for consumption or sale. This practice has latterly been largely broken up by the customs officers, who have at various times seized vessels, boats, and persons engaged in it.

A very recent development in the hook fishery and one which promises to become important has been brought about by the legislation prohibiting diving during the summer. Certain Greek boats, in order not to be idle at that season, provided themselves with dingeys and hooks during the summer of 1908. They were so successful that several continued in the fishery during the following winter and others are preparing to follow their example. Difficulties with the divers and the expense of maintaining the diving boats appear to be operating to drive other vessel owners into the business, and as the Greeks have shown themselves to be superior to the Bahama and Florida hookers, it would not be surprising if the former eventually practically monopolized all methods of sponging on the Florida coast.

In January, 1909, it was possible to institute an interesting comparison between the Greek and "conch" hookers. The former were working in deeper water and were securing a better and more valuable grade of sponges, superior to the catch of their rivals in size, quality, appearance, and curing, factors which very materially increased the earnings of the vessel and crew. This is indicated by the following records of the catch of two vessels which marketed their cargoes on the same day. The schooner *Fillmore*, manned by 10 Greeks, out 60 days and fishing in a depth of 35 to 40 feet, marketed 293 bunches of wool sponges for $1,880 and 292 bunches of yellow for $300, a total of 585 bunches, selling for $2,180. Another schooner, under one of the best masters and manned by 13 of the most skilled negro hookers, sponging for 42 days in depths of less than 30 feet, marketed 400 bunches of wool sponges for $889 and 700 bunches of yellow for $291, a total of 1,100 bunches, selling for $1,180. This was a yield of $2.16 per

man-day, while the *Fillmore* averaged $3.63 per man-day, almost 50 per cent more. The Greeks not only worked in deeper water, but by curing their catch on the boat instead of running in to the crawls at the end of each week they lost less time.

DIVING.

Prior to 1905 the methods already described were the only ones employed in the Florida sponge fishery, although Messrs. E. J. Arapian, of Key West, and John K. Cheyney, of Tarpon Springs, had each experimented with diving apparatus without material results. In the spring of the year mentioned, John Cocoris, a Greek, who had been employed in a sponge house at Tarpon Springs, became convinced that the methods employed in the Mediterranean could be successfully employed on the Bay grounds, and with the financial assistance of Mr. Cheyney he began to get together at Tarpon Springs men and material for the experiment. He secured from New York a number of his countrymen who had had experience in the sponge fisheries of the Mediterranean, remodeled a small sloop to suit the purpose of a machine boat, and in April of that year made his first trip and took a large quantity of fine sponges.

The success attending this venture produced considerable excitement among those engaged in the industry. Those interested in vessels engaged in hooking soon recognized a serious competitor in their business and raised various objections to the use of the scaphander, some of which were well founded and others baseless. In many instances the real objection was not so much the actual or alleged injurious effects upon the beds, but a belief that the divers would lower the price of sponges by vastly increasing the supply, and that, moreover, they could work with profit under market and weather conditions which would make hooking commercially impossible.

During the following winter the opposition crystallized and certain bills were introduced in Congress aiming to prohibit or curtail the use of the scaphander. The conflicting interests appeared before the Committee on Merchant Marine and Fisheries of the House of Representatives and eventually there were passed two bills partaking of the nature of a compromise. On the other hand, sponge dealers, buyers, and some vessel owners, together with a number of persons not previously connected with the industry, saw apparent opportunity for profitable investment, and during the following summer and winter great activity prevailed at Tarpon Springs, and to a minor extent at Key West, in getting together diving outfits. Diving boats were built in New York, New Orleans, and other distant places, some were even brought from Greece, and small schooners were in much demand for deposit or living boats. By May, 1906, a little over a year after the first successful experiment, there were 50 diving boats at work and 55 more awaiting crews, which could not be supplied despite a great influx of Greek

divers and boatmen. In the beginning the crews were paid wages, which under the competition for competent skilled men that developed, rose rapidly until the divers were receiving as high as $300 per month. The old system of advances or bounties, which had been the bane of the vessel owners during the preeminence of the hookers, was introduced on the diving vessels, and the owners competed against one another for the best men and even for those of little experience and ability.

These facts were soon noised abroad among the Greeks and there was a heavy influx from New York and a considerable immigration from Greece, until within a year there was a Greek colony of not less than 700 to 800 located at Tarpon Springs and more were coming on every train. A few Americans also engaged in diving, but as a rule they were less successful than the experienced men from the Mediterranean and they gradually dropped out of the business.

Cocoris's experiment was made at a particularly favorable time. The great crop of 1903, made under unusual conditions on practically virgin deep-water grounds, had been consumed, and the comparatively poor crops gathered by the hookers in the succeeding year had left the market largely depleted of high-grade goods. To allay to some extent the animosity of the users of the established method, the first diving boats went well offshore in depths of 7 to 10 fathoms, where they found sponges of large size and excellent quality for which the buyers were ready to give high prices. Each dealer was anxious to secure his full share of the product, and being uncertain as to the possible yield and the period during which it would be maintained, prices continued high throughout the year, reaching their culmination in February, 1906, when one particularly excellent cargo sold for $11 per bunch, the highest price ever paid, the usual price for divers' sponges at that time being $8 to $10 per bunch.

Between January 1 and February 15, 1906, a season when under the old methods very little was marketed, over $60,000 was produced by diving. By the middle of April about 40 outfits were at work and this number had increased to 50 by the middle of May, at which time the yield from January 1 had been no less than $250,000 and about $20,000 worth was coming in weekly. The boats properly manned were averaging about 500 to 600 bunches per month and one got 500 bunches in five days without moving much over a mile. Under this heavy supply the price broke sharply and sponges which would have brought $8 to $10 per bunch in February were selling for $2.75 to $3 in May.

Under these conditions the exorbitant wages of the earlier trips became prohibitive and the divers were placed on shares, their pay then being more dependent upon their own skill and industry. In some cases the other members of the crew were on shares, but about May 1, 1906, when wages were paid, the managers or overseers, stern oarsmen, and life-line men, received $75 to $80 per month, and the pumpers and bow oarsmen from $50 to $60. Under the

discouragement of low prices for sponges and the demoralized condition of the labor problem, some of the diving outfits were withdrawn from service and tied up, while others recently built or acquired never went into commission. Other owners, unable to deal efficiently with crews speaking an alien tongue, gave up the attempt to operate directly and chartered their boats and outfits to Greeks, who have thus gradually assumed a practical monopoly of the diving operations, though under the navigation laws it is necessary for them to employ citizens of the United States as nominal masters of the living or deposit boats.

There was also about this time a change in the quality of the product. Previously there had been but few small sponges and the large ones were perfect forms, but in May, 1906, there were many small ones in the cargoes and many of the large ones were old, ragged, and inferior, about 30 per cent of the whole being packed as cuts and seconds. One typical cargo packed as follows:

Sizes.[a]	Weight.	Per cent.
	Pounds.	
Large	41	2.44+
Ones to twos	139	8.27+
Twos to threes	140	8.33+
Threes to fours	160	9.52+
Fours to sixes	500	29.76+
Sixes to eights		
Eights to tens		
Tens to twenties	180	10.71+
Cuts and seconds	520	30.95+
Total	1,680	100.00

[a] The sizes are based on the number of sponges or pieces per pound.

The depreciation in quality was apparently due, in some degree at least, to a change in the locality of the fishery. The Greeks, feeling that they were, in a measure, interlopers, at first treated the prejudices of the hookers with considerable respect and carried on their work far offshore, on virgin or little worked beds, where the run of sponges was large and the quality good. It was stated that some cargoes came from a depth of 14 fathoms and there were reports, never properly authenticated, of diving in still greater depths, but there is no doubt that the major portion of the catch came from depths of between 40 and 60 feet. As it became more apparent that the divers were not to be seriously molested, despite the loud threats of some of the hookers, they became more confident and encroached more and more on the beds in shoaler water, where, of course, they took the same class of sponges brought in by the hookers. The arduousness of diving and its physical perils increase with the depth of water, and the divers will not work in deep water if they can get sponges in the shoaler.

The first diving or machine boats used in Florida were small sponging sloops from which the cabins were removed and which were otherwise remodeled to suit the requirements. The pump was installed in the hold, from which the hatch was removed, the sides were built up and pins or crutches, two on each side at a considerable height above the deck, were provided for the sweeps. A shorter mast was introduced and rigged with a spritsail.

It was soon found that these boats were heavy and clumsy for the work, and boats of the Greek type (pl. XXIX) were speedily introduced and are now almost universally employed. They are "double-enders" with high bows and sterns and considerable shear, making them good, dry sea boats in any weather, either under way or at anchor, and they are spritsail rigged. More recently gasoline engines have been placed on many of the boats, the propellers being guarded by cages to prevent fouling of the hose or life line, an accident which might readily prove fatal to the diver at work. The machine boats are also provided with two pairs of stout crutches, to which the sweeps are slung by rope loops or grommets, and on each side amidships is a rail about 18 inches high, with a sailcloth curtain or screen stretching to the gunwhales. When not in use the oars or sweeps rest fore and aft on the crutches. On the starboard side forward is a heavy ladder, hinged so that it can be swung outboard or stowed inboard as required, and of sufficient length to extend 2 to 2½ feet below the surface of the water. This is an essential feature of the machine boat, as without it the diver in his heavy cumbersome armor could be brought aboard only with extreme difficulty. The Greek boats have each a circular hatch forward, in which stands the man using the water glass. The machine boats of the Greek type are about 32 feet long and about 11 feet beam on deck, and, fully equipped with a good pump and gasoline engine for propulsion, cost about $2,000.

The pump is of the usual type employed in diving operations, is placed amidships in the boat and when not in use is covered by a hatch to protect it from the weather. The diving dress consists of a helmet, breastplate, shoes, and weights. The suits, which are made of several sizes to suit the physical proportions of the divers, are of double waterproof cotton cloth with rubber between and completely cover the body with the exception of the hands, a close-fitting rubber cuff being provided at the wrists, and a heavy rubber yoke or collar extending across the breast, back, and shoulders. The helmet is of tinned copper with three heavy glass windows at the front and sides and one obliquely above in front. At its back are two valves, one with a connection for the hose and the other for the discharge of vitiated air. In some helmets the latter valve is automatic, but few of the Greek divers will use this, preferring those in which the escape of air from the helmet is regulated by the diver, the valve being held in place by a spring and released by pressing against it with the

back of the head. The fresh air is conducted in flat tubes from the intake toward the front side of the helmet, serving the double purpose of supplying unvitiated air for respiration and preventing condensation on the window. The hose is of the best quality, covered with a canvas jacket to protect it from abrasion and with tight screw couplings between the sections, the weight of the unions being compensated for in the water by cork floats. The rest of the hose is of itself sufficiently buoyant when full of air.

In preparing to descend, the diver dresses in heavy woolen underclothing and stockings, and thoroughly soaps his hands and wrists to permit pulling on of the rubber cuffs and to secure closer contact at the wrists. With assistance he then crawls into his suit; the breastplate, covering the upper part of the breast, back, and shoulders, is inserted inside of the rubber yoke, which is provided with eyes fitting over corresponding screw lugs on the breastplate and the two are clamped to a water-tight joint with thumb screws and brass straps. Stout weighted leather shoes, brass soled and tipped, are then securely strapped on the feet. In the meantime the interior of the helmet has been washed and the air supply tested by placing water in the helmet to determine whether the air bubbles freely through the intake valve when the pump is operated. The pump is then started slowly and the helmet secured to the breastplate by an interrupted screw, the joint being made water-tight by means of a rubber gasket. The helmet is then lashed to the breastplate, the front and back weights of lead are lashed on, the hose brought under the left arm and lashed to the waist and the life line is fastened tightly around the body under the arms.

The diver is then ready to descend, and with his burden of about 200 pounds is assisted to the side, where he either jumps, or rather falls overboard, or else climbs down the ladder, the pump being run more rapidly as needed to supply the air pressure commensurate with the depth in which the diver is working.

The crew of a machine boat with their stations when at work is as follows: Two divers, who alternate on account of the arduousness of their duties, one resting while the other is at work; these men are always particularly abstemious as to food and drink, no alcohol being used and the daily meals consisting of a cup of coffee in the morning and a hearty dinner at night when the day's work is over. Three oarsmen; the bow oars are pulled each by one man sitting down, but the stern oarsman stands facing forward and pushes two sweeps, which are balanced by heavy weights near the handles so as to reduce the fatigue of rowing. Two pump men and one relief who manages the hose when not pumping. One life-line man, whose important duty it is to see that the life line is kept clear and that the signals of the diver are promptly regarded; experienced and careful men are required for this station, as the

Fig. 1.—Diving boat, with cured catch. Shows diver's ladder triced up.

Fig. 2.—Diving boat hauled out.

efficiency of the diver's work and not infrequently his life depend upon intelligent communication between him and the boat, while delays and misinterpretation of signals are always annoying and in case of the emergencies likely to arise in this class of work are exceedingly dangerous. One hoseman, the relief from the pump, who pays out or takes in hose as the diver moves away from or approaches the boat; a surplus of hose trailing out in strong currents impedes the diver in his progress over the bottom, and should the hose become fouled, pinched, or kinked the supply of air may be cut off with possibly serious results. When moving from place to place the hose tender relieves the stern oarsman, and the bow oarsmen and pump men alternate at their respective duties, thus obtaining some rest. On boats provided with gasoline engines there is sometimes in addition a man to run the engine.

At the present time[a] the rates of pay are based on shares as follows: The operator furnishes the boats, outfits, and provisions and receives one-half of the gross proceeds of the trip, the remainder being divided into shares, of which the divers receive 2½ or 3, the life-line tender and stern oarsman 1½, and the others of the crew 1 each.

The deposit or living boats are usually schooners, such as are commonly employed in the hook fishery, most of them between 10 and 20 tons register. They furnish the living quarters for the crew and a place of deposit for the sponges, most of which at present are cured aboard, as is done in the Mediterranean. They carry in addition to the diving crews a master, one deck hand, and a cook, the former being a citizen of the United States, as required by the navigation laws. To each deposit boat, according to its size, there are attached one or two machine boats with their crews. During the first year of the fishery one schooner was fitted for three diving crews, but it has never gone into commission, on account of the depression of the price of sponges and the lessened profit of operation. Most of the boats carry but one diving crew.

The method of carrying on the fishery is as follows: When the vessel arrives in approximately the region where she wishes to work, the bars are located by sounding with the lead or by towing a small grapnel lashed in such manner as to trip when it fouls. When a bed of suitable size is found, it is marked with a buoy and the machine boats are sent away. Since the latter have been equipped with engines, they themselves frequently search for the bars. The diver then dresses as before described and descends, taking with him a netting bag about 2 feet deep and 18 inches or more in diameter, with a hinged hoop at the top closing like the frame of an old-fashioned carpet bag. The boat, propelled either by the oars or by means of the engine, follows him in his progress over the bottom, which is marked by a stream of fine bubbles escaping from

[a] This statement applies January, 1909.

the wristbands of the suit and by sudden eruptions of large ones discharged from the relief valve, which he opens from time to time by throwing his head back against the helmet.

He regulates the air supply with two purposes in view—respiration and a proper degree of buoyancy in his suit. If all is working properly the suit is always more or less inflated, and in spite of the great weight of the man and his armor, 350 to 400 pounds as weighed in air, he treads the bottom with a pressure of but a few pounds. Should insufficient air be liberated the suit becomes still more inflated and its buoyancy will carry him to the surface, a method frequently employed in making ascent from moderate depths, but liable to produce serious hygienic consequences if practiced under greater pressures. If the pump be working too rapidly or too slowly he gives the proper signal by jerking on the life line, and the supply of air is modified accordingly.

In moving over the bottom the divers do not walk as do persons on land, a thing impossible owing to their levity and the resistance of the water. Their movements are rather a series of headlong springs or dives upward and forward with the body strongly inclined.

As the diver finds the sponges, which in the region in which the work is carried on are of but four kinds—sheepswool, yellow, wire, and grass—he tears them loose and places them in the bag, which when full he signals to have pulled up on the life line and an empty one sent down. When he wishes to come up, he gives the signal and walks toward the side of the boat, the direction of which he can determine by the trend of the life line, or else he buoys himself to the surface and is hauled in hand over hand, rotating and rolling like some monstrous form of the deep, with the air whistling and gasping at intervals from the relief valve. Reaching the ladder, he laboriously ascends with the assistance of one or two members of the crew, his helmet is taken off, and, unburdened of his chest and back weights, he comes aboard to be relieved by his diving mate.

The length of time that a diver can safely stay submerged depends upon his physical strength and endurance, but especially upon the depths in which he works. On the Florida coast, where sponging is generally carried on in less than 60 feet, the usual shift is about two hours down and two resting, but fairly good divers can stand longer shifts.

The maximum depth at which divers can work has been a matter of dispute among the spongers, but there is no doubt that they can go much deeper than they have ever yet gone on the Florida coast (about 110 feet), though at the greater depths their efficiency decreases and they become subject to serious maladies, which will be discussed later. The laws of Greece, for humanitarian reasons, prohibit diving at greater depths than 38 meters (125 feet), but it is said that the Mediterranean sponge divers sometimes work in 40 fathoms (240

feet). Siebe, a recognized authority, states that 150 feet is the maximum limit for safe diving by physically sound men, and that the greatest diving feat known is a stay of forty-two minutes in a depth of 201 feet.

The proceeds of a sponge diver's work depend upon a number of conditions—his own skill and industry, the condition of the water, and the abundance, size, and distribution of the sponges on the bottom. During the spring and summer of 1906, when the boats were working in from 40 to 60 feet of water, with good average weather conditions and sponges relatively abundant, two divers working alternately were taking on an average about 20 bunches a day, or, making allowance for time lost from various reasons, between 25 and 30 bunches per working day. One of the most successful trips averaged 50 bunches per day for each diver, or about 500 bunches in five days for the boat. For single days this average has been considerably exceeded.

During the season for diving, which under act of Congress began October 1, 1907, and closed April 30, 1908, the conditions were far from favorable, the weather especially during the winter and spring being unusually turbulent and the water almost constantly turbid. In consequence of this the divers were working closer to shore, in water of much less depth than the minimum prescribed by law, and in April I saw two boats operating even within state jurisdiction. The sponges brought in were ragged and inferior in size and quality, and many of them were, moreover, poorly cleaned. The proportion of small sponges was large, the limit prescribed by law being almost wholly disregarded, as was also the case during the season preceding. I saw large quantities of small sponges in some of the packing houses, and it is a matter of common notoriety in Tarpon Springs that many small sponges packed in bags are shipped by the Greek spongers without ever being exposed to sale at the Sponge Exchange.

Owing to the unfavorable weather the product per outfit during the season from October 1, 1907, to May 1, 1908, was much below that stated above, averaging about 300 bunches per boat per month. The total yield was $392,399, as compared with $638,766 the year before, but this was due in part to the restriction of the diving season to seven months during the period least favorable for work. The character of the catch during the season is indicated by the fact that 50 per cent of the sponges were larger than twelves, about 12 per cent were twelves or smaller, and 38 per cent were packed as cuts and seconds. The yield was inferior in quality to that of the first year of the fishery, but was about the same as in 1906, excepting that the proportion of cuts and seconds was higher.

During the winter of 1908–9 the yield of sponges on days when the weather was favorable was from 10 to 15 bunches per diving boat. The following actual

returns will illustrate the average catches during the months of December and the early part of January:

Diving boat *Amphirite*, out two months:

172 bunches sheepswool, selling for	$1,292.05
60 bunches small sheepswool, selling for	116.00
253 bunches yellow, selling for	289.50
84 bunches grass, selling for	47.00
569 bunches all kinds, selling for	1,744.55

Diving boat *Harikila*, out two months:

160 bunches sheepswool, selling for	$1,353.00
59 bunches small sheepswool, selling for	117.18
205 bunches yellow, selling for	259.00
70 bunches small yellow, selling for	34.00
94 bunches grass, selling for	55.00
588 bunches all kinds, selling for	1,818.18

Schooner *Edna Louise*, with two diving boats, out seventeen days:

250 bunches sheepswool, selling for	$1,398.00
75 bunches small sheepswool, selling for	101.00
444 bunches yellow, bid refused	248.00
115 bunches wire, bid refused	83.00
884 bunches all kinds, bid	1,830.00

These figures give an average per boat day of about 13 bunches of sponges of all kinds, selling for $35.

As compared with hooking, diving requires a more expensive equipment. The smaller vessels of the old fleet are not suitable for living boats, for the crews are necessarily large and require the same accommodations needed for an equal number of hookers, especially as the sponges are now cured on the vessels. In addition, the diving or machine boat, with its pumps, suits, and gear, is much more costly than the sponge hooks, glasses, and five or six dingeys which constitute the secondary equipment of the hooker. The expense of operation and maintenance is also greater, and to pay expenses the yield per man must be considerably larger.

To compensate for this, diving has several advantages: It can be carried on in rougher and more turbid water and at greater depths, and, moreover, the diver can get sponges inaccessible to the hooker working on the same beds. In practice, too, the diving crews can be kept more persistently at their work, and the Greeks are less prone to lose time running inshore at night unless under stress of weather. When diving was first introduced on the Florida coast it was claimed that but rarely would the sea be so turbulent as to stop operations. Experience, especially that of the last season, has shown that this fishery also is more or less at the mercy of the weather and that while it can be prosecuted

when hooking would be absolutely impossible the frequent gales and strong northers which sweep the Gulf of Mexico in winter and early spring are factors that have to be reckoned with, and the proportion of days of enforced idleness is considerable.

The turbidity of the water is also a factor, and while it is rarely absolutely prohibitive, as with the hookers, it at times more or less seriously interferes with the efficiency of operations. When the water is clear and the light good, the diver can see plainly at a distance of some yards, but on cloudy days in turbid water sponges more than a few feet away will escape notice, especially if the bottom be covered with gorgonians and similar growths. It will be readily understood that under such conditions the efficiency of the diver is much reduced, so that he must necessarily miss many sponges that would be readily found under more favorable circumstances, and that while moderately clear water is not essential, as in the earlier methods of sponging, its relative prevalence is reflected in the balance sheet at the end of a trip.

The ability of the diver to penetrate to a depth beyond that accessible to the hooker is of value only if sponges extend into the deeper water. That this is the case to some extent has already been demonstrated, but there is as yet no indication that the beds extend to depths equal to those attained in the Mediterranean. The advantage in the efficiency of the two methods at depths of 40 feet or more, where the hooker is approaching his limit, is vastly in favor of the diver, who can work there in average weather, while the hooker can operate only under very rare combinations of favorable conditions.

Finally, the diver is able to gather sponges which, while within the limits of the hooks, are so situated as to be invisible or inaccessible from above. As has been stated elsewhere, the bottom on the beds is rough and irregular, and many sponges grow in crevices, on overhanging ledges, or hidden by masses of coral, and can not be gathered by the hooker. The diver walking over the bottom can find and secure almost everything, stripping the bottom almost bare if he wishes.

KILLING AND CURING.

When a sponge is brought to the surface a certain amount of air immediately enters its pores and replaces the water in some of the canals and chambers. In this condition it will float, and the spongers, taking this as a sign of death, believe that the sponge is killed immediately upon exposure. If the floating sponge be left to itself, however, most of the entrapped air is soon expelled by the pressure of the water and it will then sink and become a "roller." The air can also be expelled without injury to the sponge by gently squeezing it under water. The hookers have always killed their catch by prolonged exposure on the decks of the vessels, the sponges being carefully placed "root" down, so as to facilitate the escape of the "gurry," or liquefied organic matter which

results from decomposition. In hot sunny weather death comes rather quickly and the internal tissues begin to slough in a day or two, but when it is cold and cloudy a week of exposure is sometimes insufficient to kill the tissues throughout, the result often being the retention of more or less hardened matter in the substance of the cured sponge, to the detriment of its value and very difficult to remove by subsequent treatment. The spongers recognize this fact, but being imbued with the idea that the sponge is dead as soon as removed from the water they ascribe it not to retained vitality but to what they call "chilling," a physical change in the fleshy substance of the sponge which causes it to resist decay. During the process of killing some care has to be exercised to prevent the skin from drying and adhering to the skeleton.

Each hooking vessel has located somewhere along shore at a point accessible to the sponge grounds an inclosure called a "crawl" or "kraal," about 10 feet square, constructed of stakes driven close together and nailed to horizontal pieces to keep them from spreading. Among the keys the crawls are usually isolated, small, and of a temporary character, but on the Bay grounds they are more substantial and grouped under the care of a common watchman to prevent the depredations liable to occur during the distant absences of the owners. The Bay fleet has groups of crawls near Cedar Keys Light and at Baileys Bluff, Sawyers, and Union Crawl, just north of the mouth of Anclote River, and at various times they have been established at other localities. In these inclosures the dead sponges are placed to macerate, the organic matter undergoing rapid decomposition and liquefaction. This method appears to have originated in the Bahamas, the first sponges produced in Florida being rather poorly cured, principally because they were not thoroughly beaten and squeezed. It is stated that for similar reasons the first product of the Bay grounds was regarded as inferior to the Key sponges and sold at a lower price.

Usually on Friday night the vessels run in to the crawls, and Saturday is spent in "crawling" the dead sponges of the recent catch and cleaning those deposited on the Saturday previous. During the week most of the fleshy matter has macerated and washed out and the remainder is removed by beating the partly submerged sponge with a short heavy stick and by repeated squeezing under water. If particles of skin adhere they are scraped off with a dull knife. The crawls are always located in salt or brackish water, as maceration in fresh water darkens the fiber of the sponge. By means of a long needle the cleaned sponges are then strung on rope yarns 6 feet long, the ends of which are tied together to form wreaths, technically known as "bunches," which are partly dried and stowed in the hold of the vessel pending the end of the trip. The approved method is to string together sponges of approximately the same size, "eye and root"—that is, with the top of one sponge against the bottom of its neighbor—but some captains will have their catch

strung so as to make the largest possible number of bunches by placing the minimum number of sponges on each, a subterfuge which rarely deceives the watchful buyer, who reduces his bid accordingly.

The diving boats at first followed the same methods, but afterwards to obviate the loss of time involved in making the weekly trips to the crawls and to save the expense of employing watchmen they recurred to the method of cleaning on the vessels, to which they had been accustomed in the Mediterranean. The sponges as taken are placed on deck and thoroughly trod under the bare feet of the crew, so as to hasten death by crushing the soft tissues. They are then hung over the side to macerate, after which they are washed out on deck in tubs of sea water. The results of this method of cleaning were at first regarded as less satisfactory than of that practiced by the hookers. Occasionally more or less solid matter is retained through imperfect killing and maceration, and in addition the water in the tubs is sometimes allowed to become thick and gelatinous with partially dissolved animal matter, which, adhering to the fiber, makes the sponge hard when dry and sticky when moist. When sponges so treated are thrown on the beach, sand and dust adhere to the surface, injuring the color and making pure goods look as if "loaded." When properly performed, however, the results are good. Less sand is picked up by the sponges than when they are rolled about in the crawls, and as the animal matter is more quickly removed there is less injury to the fiber of the sponge than if the maceration be more prolonged. The sponges are also lighter in color and cleaner in appearance, while the soluble animal matter left in the sponge by the washing in tubs is appreciated by the buyers as adding to the weight.

THE SPONGE TRADE.

Buying.—The first sponges produced in Florida were sold to one or two merchants at Key West or exchanged for goods at a fixed price of 10 cents a pound, but as the demand increased competition for the product grew also an the method of selling at auction developed.

At Key West, which held an absolute monopoly of the trade until about 1891, a wharf is set apart as a sponge market, the buyers each paying for its use a fee proportional to the amount of their purchases. Here the spongers bring their catch and spread them, sorted according to kinds, in piles arranged to show them to best advantage, the sponges being wet to swell them to their largest proportions. At appointed times the buyers assemble, and, proceeding from pile to pile, bid for each separately, basing their offers upon the number of bunches and the size and quality of the sponges. Each buyer writes his bid upon a slip of paper and hands it to the person appointed for the purpose, who when all bids are in reads them off, the highest taking the lot, though the owner may elect not to sell at the price offered. Intending buyers usually examine the

several cargoes offered before the sale begins, and the bids usually run pretty close, though I have seen a bidder, through some miscalculation and his anxiety to buy, offer 40 per cent more than his nearest competitor.

At Tarpon Springs until recently the sponges were sold at the several crawls at such times as the spongers chose to offer them. As the crawls were several miles from the town and separated from one another by considerable distances, much time was often lost in the disposal of relatively small quantities. To obviate this a sponge exchange has been organized by the buyers, who have bought a suitable site on the river near town and have erected houses and bins suitable for the storage of their purchases. The expenses of construction and operation are borne jointly by the buyers, or the houses which they represent. The actual sales follow the system already described. Tarpon Springs first became a sponge mart on a small scale about 1891, and at the end of ten years it had passed Key West in importance. With the waning of the catch on the Key grounds, and especially with the development of diving, it has now secured a practical monopoly of the business and Key West has become an almost negligible factor.

Packing.—As purchased from the fishermen the sponges are cleaned of animal matter, but they are more or less irregular where they have been torn from the bottom, and they frequently contain shells or fragments of coral and rock. After they are received at the packing house these foreign particles are removed and the irregularities and torn parts clipped off with sheep shears, the "clippers" requiring some skill to reduce the sponge to a regular shape with a minimum of waste, the work being done to best advantage while the sponges are wet. Large specimens, for which there is a limited demand, and especially those which are torn or contain crab holes, are cut into pieces with a sharp knife, the edge of which has been serrated with a file. Nearly all Anclote or Bay grass sponges, which are usually large and cup-shaped or conical, are so treated, as are at times considerable quantities of sheepwool and yellow sponges. There is always more or less loss in cutting up large sponges owing to the waste of trimming off the sharp edges left by the knife. After being trimmed the sponges are sorted according to size and quality, the whole perfect specimens being known as "forms," those with holes and similar imperfections as "seconds," while cut pieces are known as "cuts." The sizes are named from the number of "pieces" required to make a pound, the usual sizes being "ones, twos," "twos to threes," "threes to fours," "fours to sixes," sixes to eights," "eights to tens," "tens to twelves," "twelves to sixteens," and "sixteens to twenties." The "sizing" is usually made by eye, but in some cases, for greater accuracy, the sponges are passed through holes or rings.

The first sponges shipped from Key West were packed in cylindrical bales about 6 or 7 feet long and compressed by hand or treading with the feet, but within

a few years a dealer versed in the methods of the Bahama fishery introduced the present type of square bales. These vary in size according to the demands of the trade, the standard weights being 15, 30, 50, and 60 pounds. But one size, kind, and grade of sponges is placed in a bale, the pieces being packed in layers and rows, due care being exercised that when the head of the bale is opened the contents shall present the best possible appearance. A simple screw press is used for compression of the bale to about 40 per cent of its hand-packed thickness. The bales while still under pressure are sewed up in burlap and corded with jute rope ¼ or ⅜ inch in diameter. They are then weighed and marked with a card giving the date, the kind and grade, the weight, and the number of pieces. The sponges are packed almost dry, so that the pieces when relieved from pressure remain compressed until moistened. Owing to the hygroscopic character of sponges, the weight of the bales fluctuates in accordance with atmospheric conditions, moisture being absorbed in wet weather and discharged in dry, and dealers and jobbers selling sponges by the bale frequently keep their stocks in damp places for the sake of the gain in weight. When reasonably dry, baled sponges will keep for years without deterioration, but if allowed to become wet, especially with fresh water and in warm weather, they sometimes "heat" and turn yellow or orange in color, with more or less loss of strength of fiber.

During ten years or so preceding the inception of diving, owing to the limited supply of sponges and their high price, there grew up a practice of "loading" by which the weight was increased by the addition of foreign matter of various kinds. In later years this practice became so extravagant that practically all Florida sheepswool sponges were loaded to double their natural weight and in some cases the increase was 150 per cent. The fact of loading was well known in the trade and what was originally a deception became in the end a sort of legitimate fraud which deceived nobody, though the degree to which it should be practiced was a source of constant controversy between the packers and the jobbers. The process was originally fraudulent, but eventually absurd, the same amount of actual sponge being obtainable at about the same price, whether loaded or pure. In fact, a pound of pure sponge could usually be obtained at a slightly lower cost than double the quantity of goods loaded 100 per cent, the packer having to reimburse himself for the labor and materials consumed in loading. In addition, the quality of the loaded sponge was injured by reason of the gritty materials employed, which detracted from its usefulness for the finer purposes in the arts.

The methods of loading were supposedly kept more or less secret by the various packers, but, as a matter of fact, they differed only in minor details. The clipped sponges were placed in tanks containing a "dope" composed of water, glucose, glycerine, dextrin, salt, litharge, sand, and similar materials, the

whole being thoroughly stirred or tramped under foot to keep the heavier materials in suspension and incorporate them in the texture of the sponge. At first the excess of moisture was squeezed out by hand or with a clothes wringer, but later, when the desire for heavier loading became strong, the sponges were merely drained on a rack and then placed in the sun to dry.

When the supply of sponges was temporarily increased through the introduction of the diving machine and the price fell, loading was almost abandoned and most of the goods were shipped pure. But during 1908 the practice again developed, though the loading did not exceed about 25 per cent. At the beginning of 1909, with an increase in the price, there was a tendency to increase the percentage. The sand, salt, and glucose which formed the bulk of the old loading have been replaced by barytes, epsom salts, and dextrin, which are less gritty, not so hygroscopic, and more readily worked out. The present desire to increase the loading will probably induce the use of sand, as it is difficult to get the added weight without it.

Bleaching.—The sponges used in the arts are usually in their natural condition so far as color is concerned, but for bath purposes many persons prefer them bleached.

A fine whitish bleach which does not greatly injure the quality of the sponges may be imparted by repeatedly impregnating them with dense soapsuds and exposing them to the action of sun and air.

A bright yellow color, such as is generally seen in the bath sponges of the shops, may be produced as follows: Soak the sponges for about ten minutes in 5 per cent hydrochloric or sulphuric acid; then thoroughly wash in water and place in 5 per cent potassium permanganate solution until they have assumed a very dark brown, almost black, color; thoroughly wash again in fresh water and place, until almost decolorized, in a 10 per cent solution of oxalic acid. After another very thorough washing place them in a 10 per cent solution of sodium carbonate (washing soda) until they assume a bright yellow color. A very thorough washing completes the process. The fiber of all chemically bleached sponges is more or less injured by the treatment, and though softer they are inferior to the natural sponges in durability and resiliency and soon become soggy in use.

STATISTICS.

No statistics of the Florida sponge fishery are available for years prior to 1880, and no complete canvass, separate from the general fisheries of the state, was made until 1900. The following tables[a] exhibit in some detail the extent of the fishery in the years 1903 to 1908, inclusive, embracing the transition period during which hooking was largely supplanted by diving.

[a] Compiled from a canvass made by Mr. John N. Cobb, Bureau of Fisheries.

The difficulties in dealing statistically with this period have been considerable, as persons, and especially vessels, have been engaged, in many cases, part of the year in hooking and part in diving. In each such case, however, effort has been made to accredit the vessel to that method in which its activities predominated during each year.

The tables are interesting as showing not only the changes in the methods of the fishery, but also as exhibiting the shifting of the location of investment incident upon these changes. Until the inauguration of diving the investments at Key West (Monroe County) were paramount, but in 1906 Tarpon Springs (Hillsboro County) passed Key West as a center of investment, as it had done some years previously as the principal sponge market. In 1908 the capital employed in the fishery at Tarpon Springs exceeded that at Key West by about 85 per cent.

In the tables of the product for the years 1903 to 1908, inclusive, the weight is based upon the number of bunches purchased. In previous years it was determined from the pack, a method highly defective on account of the practice of "loading."

PERSONS EMPLOYED IN THE SPONGE FISHERY OF FLORIDA IN 1903–1908, BY COUNTIES.

	Monroe.	Hillsboro.	Pasco.	Levy.	Franklin.	Total.
1903.						
Vessel	1,033	84	13	16	52	1,198
Boat	700	164	----------	----------	23	887
Total	1,733	248	13	16	75	2,085
1904.						
Vessel	885	64	----------	16	50	1,015
Boat	630	112	----------	----------	20	762
Total	1,515	176	----------	16	70	1,777
1905.						
Vessel	816	177	----------	21	32	1,046
Boat	721	117	----------	----------	25	863
Total	1,537	294	----------	21	57	1,909
1906.						
Vessel	681	613	13	30	48	1,385
Boat	595	221	----------	----------	13	829
Total	1,276	834	13	30	61	2,214
1907.						
Vessel	495	570	----------	27	34	1,126
Boat	490	462	----------	----------	10	962
Total	985	1,032	----------	27	44	2,088
1908.						
Vessel	583	910	----------	----------	20	1,513
Boat	392	397	----------	----------	18	807
Total	975	1,307	----------	----------	38	2,320

INVESTMENT IN THE SPONGE FISHERY OF FLORIDA IN 1903–1908, BY COUNTIES.

Item.	Monroe.		Hillsboro.		Pasco.		Levy.		Franklin.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
1903.												
Vessels	121	$195,385	10	$11,650	1	$1,250	2	$1,750	6	$5,150	140	$215,185
Tonnage	3,521		100		12		16		50		1,699	
Outfit		64,490		4,000		300		850		2,050		71,690
Boats	200	90,300	38	13,550					5	1,900	243	105,750
Outfit		90,000		6,635						1,900		98,535
Apparatus, vessel fisheries:												
Hooks, etc		2,544		209		34		45		116		2,948
Apparatus, boat fisheries:												
Hooks, etc		2,300		318						43		2,661
Shore and accessory property		4,500		1,400								5,900
Total for year		449,519		37,762		1,584		2,645		11,159		502,699
1904.												
Vessels	107	163,065	8	9,000			2	1,750	6	4,950	123	178,765
Tonnage	1,234		79				16		49		1,378	
Outfit		55,280		3,400				750		1,875		61,305
Boats	180	77,400	24	9,300					4	1,700	208	88,400
Outfit		72,000		5,405						540		77,945
Apparatus, vessel fisheries:												
Hooks, etc		2,163		153				45		124		2,485
Apparatus, boat fisheries:												
Hooks, etc		2,340		215						36		2,591
Shore and accessory property		4,800		1,300								6,100
Total for year		377,048		28,773				2,545		9,225		417,591
1905.												
Vessels	91	153,980	[a] 17	25,600			3	2,600	4	3,400	115	185,580
Tonnage	1,158		224				22		31		1,435	
Outfit		51,540		13,995				1,450		1,375		68,360
Boats	206	88,580	23	9,400					5	2,000	234	99,980
Outfit		82,400		4,400						1,075		87,875
Apparatus, vessel fisheries:												
Diving			11	6,600							11	6,600
Hooking		1,998		217				50		79		2,353
Apparatus, boat fisheries:												
Diving			1	600							1	600
Hooking		2,678		200						45		2,923
Shore and accessory property		4,300		1,300								5,600
Total for year		385,476		62,312				4,100		7,974		459,871
1906.												
Vessels	42	40,360	[b] 47	104,450	1	1,250	4	4,800	6	4,400	98	155,260
Tonnage	345		1,083		12		36		41		1,517	
Outfit		18,480		45,815		600		1,950		1,650		68,495
Boats	170	73,100	34	16,660					3	1,250	207	91,010
Outfit		68,000		13,328						800		82,128

Apparatus, vessel fisheries:												
Diving			55	32,400							55	32,400
Hooking		681		207		34		87		124		1,133
Apparatus, shore fisheries:												
Diving			14	8,262							14	8,262
Hooking		2,210		310						25		2,545
Shore and accessory property		4,600		1,200								5,800
Total for year		207,431		222,632		1,884		6,837		8,249		447,033
1907.												
Vessels	62	62,455	[c] 47	95,780			3	3,250	4	3,350	116	164,835
Tonnage	505		1,050				32		32		1,682	
Outfit		22,328		66,195				900		1,450		90,873
Boats	140	60,200	74	36,260					2	900	216	97,300
Outfit		42,000		29,000						500		71,500
Apparatus, vessel fisheries:												
Diving			48	27,600							48	27,600
Hooking		1,016		478				84		90		1,668
Apparatus, boat fisheries:												
Diving			30	18,000							30	18,000
Hooking		1,820		450						18		2,288
Shore and accessory property		4,000		1,000								5,000
Total for year		193,819		274,703				4,234		6,308		479,064
1908.												
Vessels	[d] 72	85,705	[e] 71	145,770					2	1,950	145	233,425
Tonnage	709		1,477						19		2,205	
Outfit		26,278		74,135						740		101,143
Boats	130	65,000	56	33,850					4	1,600	190	100,450
Outfit		8,000		30,240						400		38,640
Apparatus, vessel fisheries:												
Diving	3	1,800	86	51,600							89	53,400
Hooking		1,188		469						56		1,713
Apparatus, boat fisheries:												
Diving			34	20,400							34	20,400
Hooking		910		558						28		1,496
Shore and accessory property		4,100		500								4,600
Total for year		192,981		357,512						4,774		555,267

[a] There were 11 diving boats, valued at $3,500, working with these vessels; their value, but not number, has been included with vessels.
[b] There were 55 diving boats, valued at $18,850, working with these vessels; their value, but not number, has been included with vessels.
[c] There were 48 diving boats, valued at $16,100, working with these vessels; their value, but not number, has been included with vessels.
[d] There were 3 diving boats, valued at $900, working with these vessels; their value, but not number, has been included with vessels.
[e] There were 86 diving boats, valued at $28,850, working with these vessels; their value, but not number, has been included with vessels.

CATCH BY VESSELS AND BOATS IN THE SPONGE FISHERY OF FLORIDA IN 1903–1908, BY COUNTIES, KINDS, AND GROUNDS.

Kinds and grounds.	Monroe.		Hillsboro.		Pasco.		Levy.		Franklin.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1903.												
Hook catch by vessels on Bay grounds:												
Sheepswool	141,255	$287,014	12,836	$25,520	86	$136	1,168	$2,013	3,339	$6,057	158,634	$320,740
Yellow	38,571	11,119	3,836	912	20	4	302	75	1,374	308	44,103	12,418
Grass	23,790	6,047	8,434	1,301	52	11	438	84	588	94	43,302	7,537
Total	213,616	304,180	25,106	27,733	158	151	1,908	2,172	5,301	0,459	246,089	340,695
Hook catch by vessels on Key grounds:												
Sheepswool	10,534	16,749									10,534	16,749
Yellow	3,924	1,894									3,924	1,894
Grass	10,000	2,200									10,000	2,200
Glove	3,828	579									3,828	579
Velvet or boat	571	287									571	287
Total	28,857	21,709									28,857	21,709
Hook catch by boats on Bay grounds:												
Sheepswool	10,834	13,654	16,251	24,931					2,496	2,605	29,581	41,190
Yellow	3,156	661	5,460	1,249					1,434	274	10,050	2,184
Grass	8,626	1,033	7,012	941					1,332	210	16,970	2,184
Total	22,616	15,348	28,723	27,121					5,262	3,089	56,601	45,558
Hook catch by boats on Key grounds:												
Sheepswool	20,535	32,883									20,535	32,883
Yellow	3,924	1,894									3,924	1,894
Grass	13,109	2,873									13,109	2,873
Glove	7,656	1,159									7,656	1,159
Velvet or boat	1,144	575									1,144	575
Total	46,368	39,384									46,368	39,384
Total for year	311,457	380,621	53,829	54,854	158	151	1,908	2,172	10,563	9,548	377,915	447,346
1904.												
Hook catch by vessels on Bay grounds:												
Sheepswool	121,672	235,212	9,091	11,111			1,653	3,426	3,793	5,068	136,209	254,817
Yellow	26,980	8,063	2,544	574			384	120	1,620	393	31,528	9,150
Grass	17,292	3,084	7,536	1,005			356	38	1,058	231	26,242	4,358
Wire	76	13									76	13
Total	166,020	246,372	19,171	12,690			2,393	3,584	6,471	5,692	194,055	268,338
Hook catch by vessels on Key grounds:												
Sheepswool	13,294	20,256										20,256
Yellow	4,459	2,118										2,118
Grass	9,295	1,450										1,450
Glove	2,927	388										388
Velvet or boat	879	499										499
Total	30,854	24,711									30,854	24,711

Hook catch by boats on Bay grounds:												
Sheepswool	7,972	11,863	10,029	18,037					846	1,300	18,847	31,200
Yellow	2,684	644	3,698	938					384	95	6,700	1,677
Grass	3,942	447	2,718	327					484	59	7,144	833
Total	14,598	12,954	16,445	19,302					1,714	1,454	32,757	33,710
Hook catch by boats on Key grounds:												
Sheepswool	26,589	40,511									26,589	40,511
Yellow	8,919	4,238									8,919	4,238
Grass	18,591	2,900									18,591	2,900
Glove	5,856	776									5,856	776
Wire	22	3									22	3
Velvet or boat	1,758	998									1,758	998
Total	61,735	49,426									61,735	49,426
Total for year	273,267	233,403	35,616	31,992			2,393	3,584	8,185	7,146	319,401	376,185
1908.												
Hook catch by vessels on Bay grounds:												
Sheepswool	123,343	274,412	12,867	31,713			1,858	8,063	5,757	9,703	143,825	323,891
Yellow	20,642	8,725	3,442	813			328	147	1,472	547	24,884	10,232
Grass	16,561	2,067	8,408	1,321			50	11	704	130	19,723	3,529
Wire	1,142	104									1,142	164
Total	161,688	285,308	23,717	33,847			2,236	8,221	7,933	10,380	189,574	337,816
Diving catch by vessels on Bay grounds:												
Sheepswool			9,250	47,506							9,250	47,506
Yellow			572	225							572	225
Grass			172	30							172	30
Total			9,994	47,761							9,994	47,761
Hook catch by vessels on Key grounds:												
Sheepswool	20,613	25,040									20,613	25,040
Yellow	4,586	2,345									4,586	2,345
Grass	13,510	3,983									13,510	3,983
Glove	4,387	737									4,387	737
Velvet or boat	792	450									792	450
Total	43,888	32,555									43,888	32,555
Hook catch by boats on Bay grounds:												
Sheepswool	8,233	15,427	10,387	18,574					2,026	2,924	20,646	36,925
Yellow	2,268	736	2,944	897					644	109	5,856	1,742
Grass	2,878	408	3,924	490					214	28	7,016	926
Total	13,379	16,571	17,255	19,961					2,884	3,061	33,518	39,593
Hook catch by boats on Key grounds:												
Sheepswool	41,227	50,082									41,227	50,082
Yellow	9,172	4,690									9,172	4,690
Grass	27,020	7,968									27,020	7,968
Glove	8,774	1,473									8,774	1,473
Wire	350	88									350	88
Velvet or boat	1,585	900									1,585	900
Total	88,128	65,201									88,128	65,201
Total for year	301,083	399,695	52,966	101,569			2,236	8,221	10,817	13,441	365,102	522,926

CATCH BY VESSELS AND BOATS IN THE SPONGE FISHERY OF FLORIDA IN 1903–1908, BY COUNTIES, KINDS, AND GROUNDS—Continued.

Kinds and grounds.	Monroe.		Hillsboro.		Pasco.		Levy.		Franklin.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1906.												
Hook catch by vessels on Bay grounds:												
Sheepswool	42,202	$73,799	14,964	$29,663	1,934	$4,054	8,100	$12,420	1,978	$2,613	69,178	$122,549
Yellow	7,206	2,844	2,878	796	8	2	506	190	1,890	628	12,488	4,460
Grass	2,562	708	494	110	6	1	32	7	500	101	3,594	927
Total	51,970	77,351	18,336	30,569	1,948	4,057	8,638	12,617	4,368	3,342	85,260	127,936
Diving catch by vessels on Bay grounds:												
Sheepswool			254,870	498,921							254,870	498,921
Yellow			59,022	20,525							59,022	20,525
Grass			3,412	645							3,412	645
Total			317,304	520,091							317,304	520,091
Hook catch by vessels on Key grounds:												
Sheepswool	6,283	9,284									6,283	9,284
Yellow	3,442	2,080									3,442	2,080
Grass	11,798	3,354									11,798	3,354
Glove	2,218	364									2,218	364
Velvet or boat	440	163									440	163
Total	24,181	15,245									24,181	15,245
Hook catch by boats on Bay grounds:												
Sheepswool	3,460	5,647	16,387	27,723					4,611	6,678	24,458	40,048
Yellow	352	120	4,114	1,287					596	206	5,062	1,613
Grass	98	23	2,876	412					160	45	3,134	480
Total	3,910	5,790	23,377	29,422					5,367	6,929	32,654	42,141
Diving catch by boats on Bay grounds:												
Sheepswool			63,858	112,065							63,858	112,065
Yellow			18,038	6,316							18,038	6,316
Grass			1,230	294							1,230	294
Total			83,126	118,675							83,126	118,675
Hook catch by boats on Key grounds:												
Sheepswool	12,567	18,570									12,567	18,570
Yellow	6,886	4,160									6,886	4,160
Grass	23,597	6,709									23,597	6,709
Glove	4,437	730									4,437	730
Velvet or boat	882	326									882	326
Total	48,369	30,495									48,369	30,495
Total for year	128,430	128,881	442,143	698,757	1,948	4,057	8,638	12,617	9,735	10,271	590,894	854,583

1907.												
Hook catch by vessels on Bay grounds:												
Sheepswool	38,122	61,120	11,506	14,343			2,710	3,291	3,522	6,168	55,860	84,922
Yellow	19,673	5,902	6,558	1,974			2,482	997	3,396	1,066	32,109	9,939
Grass	31,462	6,131	11,176	1,074			572	103	3,296	594	46,506	8,502
Total	89,257	73,153	29,240	17,991			5,764	4,391	10,214	7,828	134,475	103,363
Diving catch by vessels on Bay grounds:												
Sheepswool			135,598	248,617							135,598	248,617
Yellow			137,648	41,285							137,648	41,285
Grass			23,750	5,518							23,750	5,518
Total			296,996	295,420							296,996	295,420
Hook catch by vessels on Key grounds:												
Sheepswool	7,707	11,556									7,707	11,556
Yellow	4,717	1,998									4,717	1,998
Grass	13,497	3,635									13,497	3,635
Glove	490	102									490	102
Total	26,411	17,291									26,411	17,291
Hook catch by boats on Bay grounds												
Sheepswool	849	811	13,146	16,611					925	1,910	14,920	19,332
Yellow	128	33	11,410	2,255					1,434	362	12,972	2,650
Grass	1,022	117	13,282	1,772					992	141	15,296	2,030
Total	1,999	961	37,838	20,638					3,351	2,413	43,188	24,012
Diving catch by boats on Bay grounds:												
Sheepswool			48,834	82,529							48,834	82,529
Yellow			47,410	13,395							47,410	13,395
Grass			5,594	1,055							5,594	1,055
Total			101,838	96,979							101,838	96,979
Hook catch by boats on Key grounds:												
Sheepswool	15,415	23,113									15,415	23,113
Yellow	9,436	3,996									9,436	3,996
Grass	26,995	7,271									26,995	7,271
Glove	982	206									982	206
Wire	13	2									13	2
Velvet or boat	221	98									221	98
Total	53,062	34,686									53,062	34,686
Total for year	170,729	136,091	465,912	431,028			5,764	4,391	13,565	10,241	655,970	571,751
1908.												
Hook catch by vessels on Bay grounds:												
Sheepswool	43,148	58,175	14,139	13,472					1,769	1,723	59,056	73,370
Yellow	13,614	2,389	7,716	1,039					2,040	264	23,370	3,692
Grass	12,664	1,368	13,384	1,285					528	47	26,576	2,700
Total	69,426	61,932	35,239	15,796					4,337	2,034	109,002	79,762

CATCH BY VESSELS AND BOATS IN THE SPONGE FISHERY OF FLORIDA IN 1903–1908, BY COUNTIES, KINDS, AND GROUNDS—Continued.

Kinds and grounds.	Monroe.		Hillsboro.		Pasco.		Levy.		Franklin.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1908—Continued.												
Diving catch by vessels on Bay grounds:												
Sheepswool												
Yellow	2,356	$1,561	151,658	$284,014							153,014	$285,575
Grass	1,072	196	128,924	29,444							129,996	29,640
Wire	320	52	49,780	7,557							50,100	7,609
Total	56	3	8,240	1,374							8,296	1,377
	2,804	1,812	338,602	322,329							341,406	324,141
Hook catch by vessels on Key grounds.												
Sheepswool												
Yellow	23,879	30,926									23,879	30,926
Grass	4,879	2,180									4,879	2,180
Glove	6,402	1,861									6,402	1,861
Velvet or boat	327	134									327	134
Total	671	511									671	511
	36,158	35,612									36,158	35,612
Hook catch by boats on Bay grounds:												
Sheepswool												
Yellow	159	81	23,807	22,697					1,543	$2,497	25,509	25,275
Grass			8,930	1,432					1,148	230	10,084	1,662
Total			10,390	1,004					260	36	10,650	1,100
	159	81	43,133	25,193					2,951	2,763	46,243	28,037
Diving catch by boats on Bay grounds:												
Sheepswool												
Yellow			24,344	38,480							24,344	38,480
Wire			17,506	3,774							17,506	3,774
Grass			118	58							118	58
Total			5,844	946							5,844	946
			47,812	43,258							47,812	43,258
Hook catch by boats on Key grounds:												
Sheepswool												
Yellow	23,879	30,927									23,879	30,927
Grass	4,879	2,181									4,879	2,181
Glove	10,045	3,014									10,045	3,014
Wire	975	402									975	402
Velvet or boat	80	10									80	10
Total	2,010	1,532									2,010	1,532
	41,868	38,066									41,868	38,066
Total for year	156,415	137,503	404,786	406,576					7,288	4,797	622,489	548,876

For purposes of comparison and to illustrate the statistical history of the Florida sponge fisheries, another series tables have been prepared. They embrace all years for which accurate returns are available. The data for 1903 to 1908, inclusive, are summaries of the preceding tables here first published, and for the years prior to 1903 are obtained from previous publications of the Bureau of Fisheries.

The returns of the investments in the sponge fisheries prior to 1900 are incomplete or inseparable from those in other fisheries, and the same statement applies to the personnel. The yield of the fisheries is known for a longer series of years, though the earlier returns are not so fully itemized as are those for the years beginning with 1900. It will be observed that all of the tables indicate a general shrinkage in the fishery until 1905, when the success of the experiment with diving apparatus administered a stimulus and largely revolutionized the methods. Since that time there has been an increase in the total investment, the number of vessels employed, the personnel of the fishery, and especially in the volume and value of the catch, though the latter reached its maximum, so far as the sheepswool sponges are concerned, in 1906. In that year the quantity of sheepswool sponges alone far exceeded that of all kinds in any previous year in the history of the fishery, and the value was greater than that of the entire yield of the fishery in any year before or since.

In 1907 and 1908 the production of sheepswool sponges fell between 35 and 40 per cent, and to an even greater extent in value. This retrogression in the production of the highest grade of sponges was due to legal restrictions placed on diving, which became operative in 1907.

Accompanying this decrease there has been an enormous increase in the production of the cheaper sponges, especially yellow and grass, and the entrance of the previously neglected wire sponge into the markets as a valuable product. The production of yellow sponges in 1908 was about fourfold that of 1905, and about 50 per cent more grass sponges were put on the market, while 8,494 pounds of wire sponges, valued at $1,385, were marketed in 1908, and the product of 1909 will much exceed this in quantity, with a value relatively much greater than in 1908.

Diving apparatus has undergone a rapid increase, but it is probable that its maximum has now been nearly reached, and its future development will be slower. There was a steady decrease in the number of vessels and men employed in the hook fishery between 1900 and 1905, and since that year the decrease has been rapid. Between 1900 and 1908 the number of vessels and men employed in hooking each fell about 54 per cent, and the product decreased about 45 per cent. At the present time there are indications of an increase in this method of sponging, certain of the diving vessels manned by Greeks outfitting with hooks and dingeys for work during the summer, when diving is prohibited.

INVESTMENT IN THE SPONGE FISHERY OF FLORIDA, EXCLUDING SPONGE BUYING, FOR A SERIES OF YEARS.

Item.	1880.		1900.		1903.		1904.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	102	$162,050	156	$182,151	140	$215,185	123	$178,765
Tonnage	1,260		1,750		1,699		1,378	
Outfit				115,499		71,690		61,305
Boats			228	178,465	243	105,750	208	88,400
Outfit						98,535		77,945
Apparatus, vessel fishery:								
Diving				3,153		2,948		2,485
Hooking								
Apparatus, boat fishery:								
Diving				3,223		2,661		2,591
Hooking				12,375		5,900		6,100
Shore and accessory property				494,866		502,669		417,591
Total								

Item.	1905.		1906.		1907.		1908.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	115	$185,580	98(?)	$155,260	116	$164,835	145	$233,425
Tonnage	1,435		1,571		1,682		2,205	
Outfit		68,360		68,495		90,873		101,143
Boats	234	99,980	207	91,010	216	97,300	190	100,450
Outfit		87,875		82,128		71,500		38,640
Apparatus, vessel fishery:								
Diving		6,600		32,400		27,600		53,400
Hooking		2,353		1,133		1,668		1,713
Apparatus boat fishery:								
Diving		600		8,262		18,000		20,400
Hooking		2,923		2,545		2,288		1,496
Shore and accessory property		5,600		5,800		5,000		4,600
Total		459,871		447,033		479,064		555,267

CRAFT ENGAGED IN HOOKING AND DIVING, RESPECTIVELY.

Craft.	1880.	1900.	1903.	1904.	1905.	1906.	1907.	1908.
Hooking: Vessels	102	156	140	123	104	51(?)	69	72
Boats		228	243	208	233	193	186	156
Diving, machine boats					12	69	78	123
Diving, living or deposit vessels					11	47	47	73

PERSONS EMPLOYED IN HOOKING AND DIVING, RESPECTIVELY.

Craft.	1880.	1900	1903.	1904.	1905.	1906.	1907.	1908.
Hooking: Vessels	828	1,239	1,198	1,015	893	639	457	568
Boats		874	887	762	850	633	542	410
Total		2,113	2,085	1,777	1,743	1,272	999	978
Diving: Vessels					153	746	669	945
Boats					13	196	420	397
Total					166	942	1,089	1,342
Grand total		2,113	2,085	1,777	1,909	2,214	2,088	2,320

PRODUCTS OF THE FLORIDA SPONGE FISHERY, BY KIND AND GROUNDS.

Kind and grounds.	1880.		1889.		1890.		1895.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool: Bay								
Key								
Total							231,272	$363,107
Yellow: Bay								
Key								
Total							29,509	11,798
Grass: Bay								
Key								
Total							21,387	5,464
Glove: Bay							23,952	6,502
Key								
Total							23,952	6,502
Total: Bay grounds								
Key grounds								
Grand total	207,000	$200,750	$316,559	$381,087	366,772	438,682	306,120	386,871

Kind and grounds.	1896.		1897.		1899.		1900.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool: Bay					126,700	$278,390	123,017	$356,045
Key					27,000	54,000	58,294	127,218
Total	149,724	$248,196	157,476	$240,599	153,700	332,390	181,311	483,263
Yellow: Bay					28,000	7,205	32,433	18,097
Key					27,000	9,000	42,033	25,948
Total	23,655	9,318	32,362	13,082	55,000	16,205	74,466	44,045
Grass: Bay					59,400	11,819	71,686	15,516
Key					17,500	2,500	71,426	17,747
Total	44,617	11,508	128,622	29,188	76,900	14,319	143,112	33,263
Velvet: Bay							386	64
Key					8,000	4,000	6,422	5,256
Total					8,000	4,000	6,808	5,320
Glove: Bay	18,315	3,990	13,086	3,171			1,185	168
Key					10,000	1,000	11,243	1,626
Total	18,315	3,990	13,086	3,171	10,000	1,000	12,428	1,794
Wire: Bay								
Key								
Total								
Total: Bay grounds					214,100	297,414	228,707	389,890
Key grounds					89,500	70,500	189,418	177,795
Grand total	236,311	273,012	331,546	286,040	303,600	367,914	418,125	567,685

PRODUCTS OF THE FLORIDA SPONGE FISHERY, BY KIND AND GROUNDS—Continued.

Kind and grounds.	1901.		1902.		1903.		1904.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool: Bay					188,265	$361,930	155,056	$286,017
Key					31,069	49,632	39,883	60,767
Total	202,673	$422,561	133,518	$297,727	219,334	411,562	194,939	346,784
Yellow: Bay					54,153	14,602	38,294	10,827
Key					7,848	3,788	13,378	6,356
Total	62,512	39,290	56,787	31,113	62,001	18,390	51,672	17,183
Grass: Bay					60,272	9,721	33,386	5,191
Key					23,109	5,073	27,886	4,350
Total	108,748	24,210	140,682	29,765	83,381	14,794	61,272	9,541
Velvet: Bay								
Key					1,715	862	2,637	1,497
Total			8,307	4,660	1,715	862	2,637	1,497
Glove: Bay	21,627	6,679						
Key					11,484	1,738	8,783	1,164
Total	21,627	6,679	7,365	1,111	11,484	1,738	8,783	1,164
Wire: Bay								
Key							98	16
Total			230	46			98	16
Total: Bay grounds					302,690	386,253	226,736	302,035
Key grounds					75,225	61,093	92,665	74,150
Grand total	395,560	492,740	346,889	364,422	377,915	447,346	319,401	376,185

Kind and grounds.	1905.		1906.		1907.		1908.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool: Bay	173,721	$408,322	412,364	$773,583	255,212	$435,400	261,923	$422,700
Key	61,840	75,122	18,850	27,854	23,122	34,669	47,758	61,853
Total	235,561	483,444	431,214	801,437	278,334	470,069	309,681	484,553
Yellow: Bay	31,312	12,199	94,610	32,914	230,139	67,269	180,956	38,768
Key	13,758	7,035	10,328	6,240	14,153	5,994	9,758	4,361
Total	45,070	19,234	104,938	39,154	244,292	73,263	190,714	43,129
Grass: Bay	26,911	4,485	11,370	2,346	91,146	17,105	93,170	12,355
Key	40,530	11,951	35,395	10,063	40,492	10,906	16,447	4,875
Total	67,441	16,436	46,765	12,409	131,638	28,011	109,617	17,230
Velvet: Bay								
Key	2,377	1,350	1,322	489	221	98	2,681	2,043
Total	2,377	1,350	1,322	489	221	98	2,681	2,043
Glove: Bay								
Key	13,161	2,210	6,655	1,094	1,472	308	1,302	536
Total	13,161	2,210	6,655	1,094	1,472	308	1,302	536
Wire: Bay	1,142	164					8,414	1,375
Key	350	88			13	2	80	10
Total	1,492	252			13	2	8,494	1,385
Total: Bay grounds	233,086	425,170	518,344	808,843	576,497	519,774	536,049	473,823
Key grounds	132,016	97,756	72,550	45,740	79,473	51,977	86,440	75,053
Grand total	365,102	522,926	590,894	854,583	655,970	571,751	622,489	548,876

CATCH ON BAY GROUNDS, BY APPARATUS.

	1905.		1906.		1907.		1908.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Sheepswool: Diving	9,250	$47,506	318,728	$610,986	184,432	$331,146	177,354	$324,055
Hooking	164,471	360,816	93,636	162,597	70,786	104,254	84,565	98,645
Yellow: Diving	572	225	77,060	26,841	185,058	54,680	147,496	33,414
Hooking	30,740	11,974	17,550	6,073	45,081	12,589	33,454	5,354
Grass: Diving	172	30	4,642	939	29,344	6,573	55,944	8,555
Hooking	26,739	4,455	6,728	1,407	61,802	10,532	37,226	3,800
Wire: Diving							8,414	1,375
Hooking	1,142	164						
Total: Diving	9,994	47,761	400,430	638,766	398,834	392,399	389,208	367,399
Hooking	223,092	377,409	117,914	170,077	177,663	127,375	155,245	107,799
Grand total	233,086	425,170	518,344	808,843	576,497	519,774	544,453	475,198

NOTE.—All sponges from the Bay prior to 1905 and all from the Keys to date were taken by hookers.

FOREIGN SPONGE TRADE OF THE UNITED STATES.

The foreign sponge trade of the United States has attained considerable proportions, amounting to $735,571 during the year ended June 30, 1907. The growth in the imports of sponges and the sources from which they are derived are shown in the following table:

IMPORTS OF FOREIGN SPONGES INTO THE UNITED STATES.

Year.	North America.	Europe.	Asia.	Oceania.	Africa.	Total.
1875						$118,229
1880						197,431
1885						333,774
1890						416,718
1895						350,008
1900						536,303
1905	$454,070	$88,444	$181	$17		542,712
1906	453,137	107,877	3,051	2		564,098
1907	374,418	113,830	178		$31	488,426

The decrease in 1907 was in the imports from Cuba and the Bahamas and was due largely to the heavy crop of domestic sponges in the preceding year. The imports of Mediterranean sponges, with which our own product does not so sharply compete, exhibited an increase.

During the past five years the exports of domestic sponges have been as follows:

EXPORTS OF SPONGES FROM THE UNITED STATES.

Year.	Europe.	North America.	South America.	Asia.	Oceania.	Africa.	Total.	
							Pounds.	*Value.*
1903	$42,545	$6,553	$652	$311	$245		95,159	$50,306
1904	23,472	9,700	653	1,728	1,033		64,214	36,646
1905	11,645	4,773	550	1,386	26	$10	31,700	18,390
1906	27,481	14,321	544	1,359	221		50,953	43,926
1907	99,686	11,217	506	2,413	532		136,301	114,354

The heavy increase in the exports for 1907 was also due to the large crop in the preceding year, which for the time being glutted the American market and materially reduced the price of the better grades of sponges. Ordinarily it is the lower grades only that are exported.

In addition to the foregoing sponges of domestic origin there were exported foreign sponges, principally Bahaman and Cuban, to the value of $153,452 in 1905, $152,675 in 1906, and $132,791 in 1907, most of them going to France, Great Britain, Germany, and other countries of Europe and to Canada. About 90 per cent of the export trade is in New York, and practically all of the rest in various ports on the Canadian border.

V. OTHER WESTERN ATLANTIC FISHERIES.

BAHAMA ISLANDS.

The sponge fisheries of the Bahamas date from 1841, when, it is related, the value of the native product was recognized by a French sponge dealer who had been wrecked in the archipelago, and who shipped a sample lot to Paris.

Sponge grounds.—The principal beds lie on Great and Little Bahama banks, Exuma Bank, and the shoals about Eleuthera, and differ considerably in their product. The sheepswool and velvet sponges from Little Bahama Bank, especially in the vicinity of Abaco Island, are known as Abaco wool and velvet, as distinguished from "Nassau" or "Cay" sponges, coming from other parts of the Bahamas. They are soft and fine, the velvet being the best of that variety known to commerce, are packed separately, and bring a higher price in the market. It is stated that owing to the demand for these sponges and the consequent overfishing, the beds have been more or less exhausted and many of the sponges now sold as Abaco wool and velvet are in reality selected specimens from other grounds.

The Great Bahama Banks, which extend north, west, and south of Andros Island and along the Old Bahama Channel, produce large quantities of wool, velvet, yellow, and grass sponges, but these are generally open in texture, coarse, and weak, especially those from the southern and southeastern parts of the bank. Many of them grow on gorgonians (sea feathers) or corals and are frequently pierced by large holes, which mar an otherwise spherical shape. In this region all of the four varieties named generally have the lamellæ more or less thickened to form cushions or flat-ended brushes, so that they all have surfaces more or less remotely resembling that of velvet sponges. The region from which these sponges come is known to the spongers as "The Muds."

The banks about Eleuthera, which were discovered about 1883, produce a somewhat better quality of sheepswool, but not equal to those of Little Bahama Bank.

The best of the grass sponges come from Long, Acklin, and Turks islands in the southeastern part of the Bahamas, but as a rule they are packed with those from other localities. Though the larger part of the banks lie far beyond the marine league, the Bahama government assumes jurisdiction for purposes of protection and prohibits the operation of foreign sponging vessels. In 1902 or 1903, several vessels from Key West were seized on Great Bahama Bank and the masters and several members of the crews were imprisoned at Nassau, but were ultimately released. The men were well satisfied to secure their own release and escape the confiscation of their vessels, and no test was made of the legality of the procedure.

From the view point of the perpetuation of the sponge beds it is not improbable that the Bahama govenment is justified in adopting these measures and others with like purpose, for as long ago as 1875 it was claimed that the beds were becoming exhausted by overfishing. The same claim is made to-day, especially with regard to the more desirable kinds, and in view of the increased demands on the beds in recent years it is probably warranted, notwithstanding that the product has steadily grown in quantity and value.

In 1849 the total exports of sponges were valued at $10,752, and between 1850 and 1853 the average annual exportation was valued at $50,052. The averages at other periods have been as follows: 1855 to 1858, 255,300 pounds, valued at $54,097; 1866 and 1869, 625,850 pounds, valued at $164,900; and from 1873 to 1875, inclusive, 313,733 pounds, valued at $103,673.

The exports in more recent years are shown in the table below:

EXPORTS OF SPONGES FROM THE BAHAMA ISLANDS, 1880–1905.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1880	429,400	$168,125	1893	844,300	$284,282
1881	379,700	147,207	1894	893,600	286,901
1882	612,500	286,310	1895	965,200	327,690
1883	541,600	244,216	1896	1,365,900	393,291
1884	1,274,000	220,932	1897	1,228,047	437,038
1885	808,200	254,498	1898	1,207,683	472,933
1886	676,500	215,918	1899	1,124,585	407,414
1887	622,300	229,118	1900	1,165,406	505,462
1888	789,044	238,198	1901	1,517,597	[a] 665,890
1889	703,163	251,598	1903	1,515,626	506,310
1890	917,784	306,195	1904	1,407,958	512,732
1891	987,400	284,607	1905	1,486,128	551,702
1892	1,011,200	317,888			

[a] 15 months, January 1, 1901, to March 31, 1902.

It will be observed from the foregoing that the exports have shown a steady increase during the past twenty-five years, and as practically the entire catch is shipped abroad the statistics cited can be regarded as an index of the yield of the fisheries. During the decade ending with 1889 the average annual product was 683,640 pounds; in that ending with 1899 it was 1,054,569 pounds, while for five years ending with 1905 it was 1,350,993 pounds.

There is here no intrinsic evidence that the beds are being depleted, but in the absence of data showing the intensity of the fishery no conclusions of value can be reached. There are no details available which would permit a comparison of the catch per man, though there is unofficial authority for the statement that "about 3,000 men and boys" were employed in the fishery about 1880, while official returns show that more than twice that many were employed in 1902.

Methods of the fishery.—The methods of fishing for sponges in the Bahamas are essentially those which have been described as in use in Florida prior to the introduction of the diving machine in 1905, and the history of the development of the industry is parallel. Practically all of the sponges are taken by means of hooks, by poling and sculling, though a few are secured by wading and naked diving. The methods of curing and packing are the same as those employed in Florida and the entire product passes through the sponge exchange at Nassau.

In 1902 there were employed in the fishery 265 schooners of from 5 to 43 tons and 322 sloops of from 1 to 16 tons, in all 587 vessels with an aggregate tonnage of 5,952. Attached to these vessels were 2,517 dingeys and crews numbering 5,517 men and boys. In addition there were engaged in the shore fisheries 291 boats and 445 men and boys, while the packing houses employed 258 persons.

The sponge fishery is the most important industry of the islands and over half of the product is shipped to the United States. The following statement shows the exports for 1905:

EXPORTS OF SPONGES FROM THE BAHAMA ISLANDS IN 1905.

	Pounds.		Pounds.
United States	864,658	Russia	10,441
Germany	254,494	Canada	1,457
Holland	158,488	Italy	4,396
France	95,715		
United Kingdom	95,499	Total	1,485,148

CUBA.

Sponge grounds.—The sponge beds of Cuba are found on both the north and south coasts, the latter supporting the more important and productive fishery. There are a few inferior sponges, principally a hard quality of velvet, on the north coast of Pinar del Rio, but the productive beds of the north coast are all among the numerous keys between Cardenas and Nuevitas. These beds were known before the discovery of the Batabano grounds and were resorted to by the Bahama spongers under license from the Spanish authorities. They lie in shallow water within and about the line of keys which skirts the Nicholas and Old Bahama channels, opposite the important beds of the Great Bahama Bank. It is stated that these beds have become greatly depleted by overfishing and

they now produce but about 20 per cent of the total product of the Cuban fishery. This region is the source of practically all of the Cuban reef, hardhead, and silk grass sponges. Sheepswool and velvet are now comparatively scarce, but the former are stronger and better than the product of the south coast. Certain vessels from Key West which visited this region in 1898 or 1899 reported comparatively few sponges and returned with practically none. Caibarien is the principal center of this fishery, but some of the product is sold in Cardenas and Nuevitas. There are one or two buyers located on the coast, but it is also periodically visited by buyers from Batabano.

The most important beds of the south coast lie in the vicinity of Batabano, between the main island and the Isle of Pines, from Cayos de Felipe to Cabeza del Este. This region is dotted with numerous small islands, keys, and rocks, and over most of the bottom the depth is less than 3 fathoms and in very few places does it reach a maximum of 6 fathoms. Outside of the banks in the Caribbean Sea, however, the bottom slopes rapidly to profound depths. Sponges are also found among the keys and shoals off Santa Clara Province, but no commercial fishery has been developed in that locality.

The grounds off Batabano were discovered in 1884 and an attempt was made to secure a concession monopolizing the exploitation of the beds. Fortunately this was frustrated and the beds were reserved as a common fishery. In 1891 there were upward of 180 spongers at Batabano alone, and the yield of the fisheries in that region was valued at about $110,000 per year. Since then there has been a heavy increase in the yield and the annual product is valued at about $275,000 to $350,000, as based on the declarations for export. As a general rule, however, the imports into the United States are subjected to revaluation, and it is difficult to arrive at a definite estimate of the first value of the fishery to the spongers.

The exports, which represent the entire catch for both coasts, for the fiscal years ending June 30, 1903–1906, have been as follows:

EXPORTS OF SPONGES FROM CUBA, 1903–1906.

Exported to—	1903.		1904.		1905.		1906.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
United States	381,462	$146,076	332,534	$155,099	366,388	$200,296	325,872	$161,622
France	357,410	210,589	384,478	231,140	185,427	114,438	195,683	133,062
United Kingdom	47,934	13,470	38,612	12,242	19,897	7,764	23,008	8,818
Spain	48,726	13,819	35,607	9,398	18,301	8,319	26,514	13,400
Germany	20,288	7,500	57,449	23,581	11,730	6,028	19,883	9,629
British West Indies					13,900	2,952	110	40
Canada	1,243	1,800			2,055	840		
Holland	2,200	1,000			2,013	750		
Belgium	3,148	850	2,285	1,200				
Italy			1,712	368				
Mexico			392	280				
Total	862,411	395,104	853,069	433,308	619,711	341,387	591,070	326,571

I have not been able to obtain reliable data showing the quantity of sponges shipped in preceding years, but for 1900 to 1902, inclusive, the average annual value of the exports was about $460,000. It will be seen, therefore, that during the past four or five years there has been a steady shrinkage in the value of the catch and a still greater falling off in its quantity. Between 1903 and 1906 the quantity of sponges exported, and presumably the quantity fished, shrunk over 30 per cent.

Methods of the fishery.—After experiment with the scaphander and naked diving, both of which proved expensive or inefficient, and with a species of grapnel dragged over the bottom, the method of hooking, essentially similar to that practiced in Florida and the Bahamas, finally became established as the most satisfactory and effective and is now generally employed, though a few sponges are taken in the shoaler waters by wading.

The first spongers were former Spanish sailors from the Balearic Islands, but there are now a number of Greeks and Cubans engaged in the fishery. The sponges are cleaned as in the United States and are then strung on cords, each holding a dozen sponges of uniform size or half that number of larger individuals.

They are sold at auction by the merchant owning or outfitting the vessel instead of by the master, as in Florida, being hung up in festoons for inspection for some time before the sale. There is no regular sponge exchange, as at Nassau and more recently at Tarpon Springs, the sales being conducted in some convenient coffee house, where the buyers congregate and hand in the bids on slips of paper, the highest bidder securing the lot. The method of stringing the sponges by sizes and count which is established by law is more systematic than that followed in Florida, and the buyer can more readily determine the value of the cargoes offered for sale.

MINOR FISHERIES.

Honduras.—Sponges are found along the entire coast of British Honduras, in the shallow waters about the numerous islands, rocks, and banks, but they are inferior in quality and not many are placed on the markets. The varieties found are sheepswool, velvet, and grass, the latter almost worthless. Many of the sheepswool, velvet, and grass sponges grow attached to staghorn corals and gorgonians, the removal of which leaves large holes penetrating the cured sponge and detracting from its value. Others are irregular from growing among marine growths or on the sides of rocks. The characteristics of some specimens, however, lead to the expectation that better grades will be found in deeper water. The velvet sponge in particular has some good qualities.

The value of the exports of sponges to the United States during recent years has been as follows: 1903, $1,218; 1904, $50; 1905, $915; 1906, $1,949, and 1907, $2,331.

Nicaragua.—A very few sponges are produced on the coast of Nicaragua and other Central American countries. In 1905, the exports to the United States were valued at $50.

Mexico.—The sponge beds of Mexico lie on the north and east coast of Yucatan, on Campeche Banks and about Cozumel Island. The beds which have been exploited lie in very shallow water and the sponges are very inferior, but it is said that there are better grades in the deeper water toward the southern end of the east coast. The exportation from Mexico is very small, in 1906 amounting to but $218 on shipments to the United States and $250 on shipments to France. During the five years from 1903 to 1907, inclusive, the total exports to the United States were valued at but $1,214. A very few American vessels have sponged off the Mexican coast in recent years, but the value of their catch is not definitely known. Several years ago a vessel with two diving boats operated for three seasons off Cozumel. Large yellow sponges were found in abundance, but the few sheepswool sponges taken were so much inferior to those of Florida that the venture never paid.

Colombia.—The United States consul at Cartagena says, in 1907:

> The bay of Cartagena is rich in sponge beds, and the local fishers for sponges find some fine in quality and large in size. These are handled in a crude way by the "bum-boat" men only, and sold alongside vessels in the harbor, no effort being made to export them in a business-like manner.

The Consular Reports for 1903 noted the granting of concessions on both the Atlantic and Pacific coasts which included the sponge fisheries, but nothing is known of the value of the beds. The only Colombian sponge of which the author has definite knowledge is a hardhead closely resembling that from Honduras. This is said to be very abundant. The writer ventures to predict that the sponge fauna will be eventually found to embrace all of the principal kinds of American commercial sponges, though it is doubtful whether they will prove of very high quality.

Venezuela.—Weil states that there are sponges on the coast of Venezuela, but that they are hard, incompressible, not very porous, and practically worthless.

Jamaica.—A few velvet sponges, elsewhere described in this paper, are taken from the waters of Jamaica, but the fishery is of comparatively little importance.

Santo Domingo.—The principal sponge beds are about the Island of Gonaves, in the Republic of Haiti. They produce velvet and reef sponges which are both inferior in quality and generally poorly prepared for the market. The spongers are Greeks, 5 or 6 in number, and fishing but occasionally produce sponges with a value of but $600 or $800 per year.

Commercial sponges similar in general to those of other parts of the Caribbean are known zoologically from Porto Rico, the Danish West Indies, and other of the Lesser Antilles.

VI. SPONGE FISHERIES OF THE MEDITERRANEAN AND CONTIGUOUS WATERS.

The Mediterranean produces the finest and most valuable sponges known to commerce, but they differ greatly in quality in different regions. Broadly speaking, the commercial varieties are five in number—the Turkey cup, toilet, zimocca, elephant ear, and honeycomb; but these are subdivided in the sponge trade into numerous sorts in accordance with the localities from which they come and the means by which they are taken, and then are still further distinguished by grades of quality and even by the nationality of the fishermen who take them. Sponges are found along the European, Asiatic, and African shores from Gibraltar to Port Said, but it is in certain places only that they exist in such numbers as to support a fishery. These regions will be taken up for consideration in more detail hereafter.

West of Sicily and Cape Bon, in Africa, the fishery is unimportant and almost negligible, and the finer varieties, the toilet and cup sponges, are practically absent. To the eastward of a line between the places mentioned the fishery is highly important and one of the most valuable in the Mediterranean. Owing to long-continued overfishing the supply from the Adriatic, the Ægean, and the Levant is smaller than formerly, and to meet the increased demand of the markets there has been in the last twenty-five to thirty years a most important development of the fisheries of the African Coast from Alexandria to the western frontier of Tunis.

The very finest grades come from the Levant, and the quality falls toward the westward along both the north and south shores. In the waters contiguous with the Mediterranean Sea, commercial sponges are known from the Dardanelles, the Sea of Marmora, the Bosphorus, and the adjacent parts of the Black Sea, but the quality appears to become progressively lower and the quantity less in the order named. In the Red Sea there are said to be vast quantities of sponges, but their quality is inferior and their value small.

It is difficult to form more than an estimate of the value of the Mediterranean sponge fisheries, owing to the nomadic habits of most of the fishermen. The Greeks, both national and Turkish, carry on their operations not only at home but in almost every part of the sea which promises anything like a lucrative return. The Italians, while not quite so wandering, extend their operations across the Mediterranean to the Tunisian coast, and both they and the Greeks vary somewhat in their practice of marketing their catch, sometimes selling it in the native markets but often carrying it to their home ports, where its identity is lost by mixing it with the products of other localities.

In the following pages an endeavor has been made to present such statistical information as is available relating to the number of men and boats engaged and

the value of the product. The transshipments between the various markets make it difficult, if not impossible, to state the value as a whole, and while the available figures, official and otherwise, have been used, the following must be regarded as an estimate:

Spain and France (estimated)		$9,000
Adriatic:		
Istria and Dalmatia (estimated)	$10,000	
Gulf of Taranto (1902)	22,000	
		32,000
Ægean Sea, including Crete and sponges brought from the African coast and Lampedusa (1901)		1,090,000
The Levant		113,000
Tripoli (1904–1905 average)		237,000
Tunis (1904)		435,000
Lampedusa, etc. (1904)		123,000
		2,039,000

This does not include the sponges sold at Benghazi nor the Egyptian catch, but as there are undoubtedly some duplications, it may be assumed with some assurance that the annual product of the Mediterranean fisheries is valued at not far from $2,000,000. The various fisheries, considered more in detail, are as follows:

SPAIN AND FRANCE.

For years sponges have been known to exist on the Spanish coast, but until recently practically no attempt was made to develop a fishery. Explorations during the past few years have developed the existence of workable beds about the Balearic Islands and on the adjacent coasts of Catalonia and Valencia, particularly on the banks in the vicinity of the Columbretes Islands between Majorca and the Spanish Peninsula, and a small quantity of elephant-ear, zimocca, and honeycomb sponges have been taken there with scaphanders. The Spanish Government has taken steps to encourage the industry, and in 1903 there were 10 Greek diving vessels at work, but in 1904 these had dwindled to 2, and since then there have been none. Sponges are also found on the coast of France east of Marseilles, but they are scattered and few in number and have not been commercially exploited. Zimocca, elephant-ear, and honeycomb sponges are also found off the southern coast of Corsica and of recent years have been taken in small quantities by means of the diving machine.

ADRIATIC SEA.

The sponge beds of the Adriatic appear to have been always less prolific than those of many other parts of the Mediterranean, and they have suffered so severely from the fishery that they are now of comparatively little importance.

They occur about the shores of the numerous islands of the Istrian and Dalmatian coasts south of Trieste in a depth of water not exceeding 10 fathoms.

According to Faber, the toilet sponge comes from the vicinity of the islands of Incoronata and Zara Vecchia, the zimocca sponge is confined mostly to the coast of Istria, while the honeycomb sponge is generally distributed along the coast. The honeycomb or horse sponges of the Adriatic are rather brittle and inferior to those from other localities. The fishery employs from about 150 to 200 men, who fish from small boats by means of harpoons and tongs during the good weather between March and October. The average catch per boat manned by two men is said by Faber to be about 300 to 400 pounds per year, the total yield being about 32,000 pounds, worth about $10,000.

In 1902 about 11,000 pounds of sponges of good quality, valued at from $1.80 to $2.30 per pound, were taken in the Gulf of Taranto. This small fishery is carried on mainly by Italians, but in 1901 seven Greek boats, manned by 28 men, took about 1,500 pounds of sponges, which were marketed in Greece at about $1.30 per pound.

ÆGEAN SEA AND ASIA MINOR.

The sponge beds about the Greek and Turkish islands of the Archipelago and along the coast of Asia Minor have been important from ancient times and have produced a race of bold and hardy fishermen, who have gradually extended their operations into all parts of the Mediterranean and within the last few years to the waters of the Gulf of Mexico and the Caribbean Sea.

The beds are scattered generally over the Ægean, in the Gulf of Salonica, the Dardanelles, the Sea of Marmora, and the Bosphorus, but the principal centers of the fishery are in the Cyclades and Sporades, about the islands of Rhodes, Cos, Symi, Calymnos, Samos, Patmos, Hydra, Kharki, Kramihdi, Ægina, and Crete.

In these waters the sponges are taken by naked diving, the harpoon, the dredge, and the scaphander. The first two methods are the older, the last two having been adopted at a comparatively recent date. The fishery with the scaphander is now prohibited in the waters of Samos and Crete, and the advisability of expelling it from the waters of the Cyclades has been the subject of animated though futile debate in the Greek Parliament.

The sponge beds of this entire region are much less prolific than formerly, and much of the blame is ascribed to the diving machine. Many of the best sponges are now found in crevices, caves, and under overhanging rocks which abound along the shores of the islands of the Ægean, and being inaccessible to harpoons and dredges are taken only by the divers, especially those not using the diving dress. These sponges are generally denser and finer than those more directly exposed to the light.

All varieties of Mediterranean sponges are found in these waters. The honeycomb sponge of the Cyclades is rather coarse and open in texture, but in Crete and many of the other islands it is of excellent quality. The other varieties are generally excellent, but not equal to the Syrian sponges, though those from the vicinity of Smyrna are coarse and open in texture and inferior in quality.

The sponge fishery is the most important and profitable of the fisheries of the Ægean and it ordinarily employs between 4,000 and 5,000 men, accurate statistics being difficult to obtain, owing to the nomadic habits of many of the spongers who, as it has been stated, travel to all parts of the Mediterranean.

During the summer of 1903, 318 vessels under the Greek flag alone employed 2,494 men in the sponge fisheries. There were 134 vessels, using 158 diving outfits, upon which there were employed 599 divers and 1,255 others. Thirty-six vessels with gangavas (dredges) employed 173, while 122 craft engaged in harpooning were manned by 443 persons. The operations of these vessels appear to have extended over a considerable part of the Mediterranean, and two crafts were used solely in the transportation of supplies to the African coast.

In 1900 sponge fishers of the Sporades produced about $900,000 worth of sponges and in 1901 about $810,000 worth, and in the same years there were exported from Piræus $171,791 and $280,048 worth, respectively, but undoubtedly a considerable proportion of these were taken on the African coast and the banks of Lampedusa.

The commander of the Greek hospital ship *Kreta* estimated that the Greek spongers took, in various parts of the Mediterranean in 1902, about 350,000 pounds of sponges, valued at about $1,000,000. In 1902 the exports from Piræus were valued at $214,180. In 1901 toilet sponges from the Sporades averaged from $8 to $13 per pound and honeycomb sponges from $2.75 to $4. The United States consul at Smyrna writes that during more recent years the price was from $4.65 to $15.60 per pound.

The sponge fisheries of Crete are important, but the island has neither a local market nor native fishermen. The spongers are all Greeks from the Grecian and Turkish islands, who arrive on the grounds in the spring and in the fall return to their native places with their catch. From 150 to 200 vessels and boats, manned by from 800 to 1,000 men, engage in the fishery, which produces an annual product valued at about $160,000 to $200,000. This revenue is included in that before given for the Grecian and Turkish isles. The fishery is carried on by harpoons, naked divers, and dredges, the first paying an annual license fee of $18 and the last two $46 for each boat. The revenue of the government is from $4,000 to $5,000 per year. The use of the scaphander is now prohibited, mainly for humanitarian reasons, but also on account of the depletion of the beds, which were formerly much more productive.

THE LEVANT.

In this region the sponge beds surround the island of Cyprus and skirt the Syrian coast from the Gulf of Alexandretta to the vicinity of Latakia and from Jaffa to the Suez Canal. It is stated that about May, 1907, a new bed was discovered, stretching off Port Said toward the north and northeast for a distance of about 50 miles.

The same methods are followed as in the Ægean, and a very large proportion of the spongers come from that region. The scaphander was recently prohibited both at Cyprus and on the Syrian coast, though it is reported that several diving boats have been quite recently at work in the latter locality despite the prohibition. Cyprus has lately rescinded the prohibition of the diving machine, but the regulation excluding the gangava or dredge is still in force.

The American consul at Beirut estimated in 1902 that the annual export of Syrian sponges for several years preceding had averaged about $85,000 in value and that the product was gradually decreasing, owing to the depletion of the beds. According to Simmonds, the average yield about thirty years ago was from $100,000 to $125,000 per annum. From Cyprus the exports were valued at $10,425 in 1898 and $28,835 in 1899, but it would appear that this may not represent the entire product of the island. The principal markets are Tripoli in Syria and Latakia. The sponges produced in both Cyprus and Syria are the very finest quality of cup and toilet sponges, although it is said that those on the south side of Cyprus are inferior. The very finest are sold by the piece and may bring $50 to $100 per pound, but the usual price is between $15 and $35 for the fine levants.

EGYPT.

The sponge beds off the Egyptian coast extend from the vicinity of Alexandria to the Tripolitan frontier, and are practically continuous with the sponge grounds which reach along the Tripolitan coast to and beyond Benghazi. The sponges, especially those of Mandruka, are of excellent quality, but on the whole are not equal to those of the Ægean and the Syrian coast. The spongers are principally Greeks from the Archipelago, who were colonized at Marsa Matruh by the Egyptian government in 1902. The fishery appears to be prosperous and is carried on without the use of the scaphander, which apparatus has been interdicted for hygienic and humanitarian reasons, vessels using it being subject to confiscation. The dredge is restricted to depths greater than 80 meters (262 feet), and is subject to an annual license impost of $50 per boat, the tax for harpooning and naked diving being $25 per boat. There has recently developed some difficulty in the enforcement of the regulations, owing apparently to the beds being beyond territorial jurisdiction and the spongers beyond the authority of the Egyptian government.

TRIPOLI.

The sponge beds of Tripoli extend between the Gulf of Bomba and the region about Benghazi and from Misrata to the frontier of Tunis. In the western region some of the banks are as much as 20 miles from shore and produce a better quality of sponge than in the waters nearer the coast.

Most of the fishery is carried on during the warmer season from April to October, but a few of the more hardy crews of divers work at other times. The fisheries on the banks between Tunis and Misrata, which are known especially as the "Tripoli grounds," from Tripoli-in-Barbary, their headquarters and market place, appear to have been exploited first about 1889. In 1890 they produced a value of $58,398, and their average annual product during the next nine or ten years was valued at about $165,000 per annum. The exports in 1904 were $337,750; in 1905, $226,196; in 1906, 232,565; in 1907, $213,300, and in 1908 were estimated at $175,800. In 1898 there were engaged in this fishery 53 scaphander vessels with crews of 963 men, and 25 dredges with 150 men. The former are mostly Greek, but there are a number of vessels flying the Turkish flag and manned by Greeks from the Sporades. The trawlers, or dredgers, are principally Italian. During the active fishery the Greek Government maintains at Tripoli a shore hospital and a hospital ship, to care for the divers and sailors meeting with accident or injured by the reckless use of the diving apparatus. Four methods of fishing are practiced; naked diving, harpooning or hooking, dredging, and diving with the scaphander. The latter method predominates, and of late years harpooning and dredging are said to be falling into disuse. The fishery appears to have reached its maximum development, despite efforts that have been made for its increase. The Turkish Government imposes a license tax upon the vessels, graduated from $147 per annum for scaphanders to $18 for boats employed in harpooning. Boats engaged in naked diving are taxed about $45 each, and trawlers pay about $13 if measuring 5 tons or under and $26 if above 5 tons.

The sponges from these grounds are darker in color and inferior to those from the Ægean Sea and the Levant. The first quality of bath sponges, which comes from the rocky bottoms, formerly brought from $1.50 to $1.90 per pound and the second quality, from the grassy bottoms of the channels, from $1.15 to $1.50 per pound. Recently prices appear to have appreciated, the American consul at Tripoli in Barbary stating in 1908 that sponges from rocky bottom sold for $2.73 to $3.64 per pound, those from shingle bottom for $2.05 to $3.07, and those from grassy areas for $1.91 to $2.39. He states further that an average catch for a machine boat with 12 to 14 divers is $6,000 to $7,000 a season, and that a boat with 4 or 5 naked divers will average about $1,200. About one-fourth of the product is marketed in Tripoli, the remainder being carried home by the foreign fishermen and mixed with inferior or medium grades coming from other localities.

The sponges from the Bay of Bomba and neighboring parts of the Tripolitan coast, which are generally known in the markets as Benghazi sponges, are much superior to those above described and will sell for from two to four times the price of Tripoli goods. In 1908 bath sponges sold for $6.20 per pound, toilet sponges for $8.22, and cup sponges for $13.65. The bath or honeycomb sponge of Benghazi is hardly inferior to that of Mandruka and most of the better ones are sold as such. The annual product of this region is about $75,000 to $90,000.

All types of Mediterranean sponges are found on the coast of Tripoli, but zimoccas and honeycombs are more common, especially on the Tripoli grounds.

TUNIS.

The Tunisian sponge beds lie between Bibau and Sarsis near the Tripolitan frontier, about the island of Gherbis, in the Gulf of Gabes, in front of Sfax between Mahares and Mehedia, about the Kerkennah Isles, and along the coast in front of Monastir and Susa.

Sponges are taken on these coasts by wading, naked diving, harpooning, dredging, and diving with the scaphander. The seasons vary with the method. Naked diving and harpooning are carried on in general from October to January, at the time when the bottoms are cleaned of vegetation and the sponges can be plainly seen, but the use of the scaphander and the dredge is physically possible throughout the year.

Wading is practiced by natives only, especially those of Kerkennah and Gherbis; the harpoon is employed by natives, Sicilians, Maltese, and Greeks; the dredge is used by Sicilians and Greeks, while the latter alone employ the scaphander. The Tunisian government has recently interdicted the use of the scaphander during November and December and has restricted the number of licenses to be issued. In 1904–5 the maximum was 22.

In 1904 the fishery gave employment to 1,368 vessels and boats, of which 522 were Italian, 79 Greek, and 767 Tunisian, upon which were employed 1,688 Italians, 444 Greeks, and 2,299 natives, a total of 4,431 men. Gourret says that in 1896, an average year, there were engaged in the fishery 1,089 vessels, measuring 2,371 tons and manned by 3,201 men, in addition to which there were 169 persons taking sponges afoot (wading). In 1854 there were but 102 boats, and in 1882, according to Henneque, 572 boats and vessels—Sicilian, Greek, and native.

Following is a table of the product for various periods since 1854:

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1854	26,400	$12,000	1894	254,000	
1884–85	206,000		1896	222,000	$224,000
1885–86	197,000		1900	211,200	
1890	245,000		1904	234,000	434,900
1892	200,000	237,700			

Judging from the statistics alone, the fishery seems to have been well maintained during the past twenty years.

The sponges of Tunis are inferior to those of Tripoli and average from 10 to 20 per cent less in price for corresponding kinds. Those taken by the gangava or dredge bring a lower price than the product of either the harpoon or scaphander, probably on account of their miscellaneous character as to both size and quality. Many of the native spongers sell their catch in its natural or uncleaned condition (pêche noire), but the foreign fishermen all clean their product (pêche blanche) before selling it.

The Tunisian Government has followed a vacillating policy in regard to licenses for the fishery, especially as to the scaphander; but in 1903 the annual fees were fixed at $20 for harpoons, $75 for dredges, and $200 for scaphanders. For the "pêche noire" the tax is $8 per boat, all sponges to be landed and sold in the uncured state.

Sfax and Gherbis are the principal markets, whence a large part of the product is shipped to Marseilles. Owing to the imposition of an import duty in France there is a growing tendency to ship to London.

LAMPEDUSA AND THE SICILIAN SEA.

The sponge fishery in these waters is carried on from March until about the middle of November, principally on the banks stretching south and southwest from Lampedusa almost to the coasts of Tripoli and Tunis, but also to some extent north of Pantellaria and off the west coast of Sicily. The fishery is almost solely in the hands of Italians and Greeks, although a few Turkish and Tripolitan vessels are occasionally engaged in it. In 1904 there were 63 Italian vessels of 1,302 tons carrying 309 men and 37 Greek vessels of a total tonnage of 716 and carrying 406 men. The vessels range between 10 and 40 tons.

Three methods are employed in the fishery—harpooning or hooking, dredging, and diving with the scaphander. The native fishermen use the first two methods solely, while about half of the Greeks employ the diving dress. The Italian fishermen are practically all Sicilians, though a few come from Naples.

In 1904 the product was about 81,000 pounds, valued at $123,000, as compared with 98,000 pounds, valued at $150,000, in 1903 and 68,000 pounds, valued at $85,000, in 1902. Both the product and the number of persons engaged in the fishery have decreased since 1899.

The Italian spongers sell most of their catch at Lampedusa, whence it is shipped to Palermo, Leghorn, Milan, Ancona, Venice, Trieste, Paris, Marseilles, and Barcelona. Those taken by the Greek divers are carried to Piræus, where those of the best grade, which come from the bank of Mezogiorno, bring about 20 per cent more than in Lampedusa. In 1904 the sponges taken with the gan-

gava brought about $1.80, and those caught by the divers from $1.80 to $2.90 per pound, the product of the scaphander being superior in quality as well as larger.

The sponges taken on the banks of Lampedusa and the Sicilian Sea are Turkey cup and toilet, elephant ear, zimocca, and honeycomb. They vary in quality on the different beds.

ALGERIA AND MOROCCO.

There are sponges on the coast of Algeria, but beds extensive and rich enough to warrant a fishery are unknown. The elephant ear was recorded from Bona many years ago, and a toilet sponge similar to that of the Adriatic has been found at LaCalle, Philippeville, and other places on the coast. Within a few years the Spaniards have explored the coast of Morocco and have found beds capable of commercial development.

METHODS OF THE FISHERIES.

The methods followed in fishing for sponges in the Mediterranean, though differing somewhat in details, are essentially the same as those employed on the coast of Florida, with the addition of nude diving (which though occasionally practiced on the American coasts has never been of any importance commercially) and dredging.

Wading.—This was probably the primitive method of sponging in the Mediterranean, as it was in Florida, but with the extermination of the sponges in shoal water it has long disappeared as a factor in the fishery, excepting on the coast of Tunis. The natives of Gherbis and the Kerkennahs take a few sponges in this manner, wading in the water to their necks when the sea is smooth, detaching them with their toes and kicking them within reach of the hands, and occasionally diving into the holes where the water is slightly deeper. The sponges taken by this method are inferior.

Nude diving.—This is another ancient method and a logical sequence of the preceding. It is practiced principally by the Greeks of the Archipelago, the Syrians, and natives of the Tripolitan and Tunisian littorals. It is said that the most skilled naked or "common" divers are from the islands of Calymnos and Symi, and that some of them can descend to the enormous depth of 240 to 250 feet. If this be true it is far in excess of the depths reached by ordinary divers, which usually do not exceed 150 feet. They ordinarily remain under water about two minutes, resting about thirty minutes between dives, but experts sometimes stay down four minutes, and it is stated on good authority that two extraordinary divers of Calymnos remained under water over five minutes, though the depth is not stated.

To aid their descent the divers hold in their hands a flat stone (scandli) attached to a cord, the other end of which is held by a man in the boat. When

the bottom is reached the stone is dropped, the diver retaining hold of the cord to prevent floating, while he gathers the sponges within reach, which are deposited in a net bag attached to his waist. His desire to come up is signaled by jerking on the cord.

The nude divers are not attacked by the serious maladies to which the machine divers are subject, and despite the arduousness of their calling are able to follow it for years, but owing to the brevity of their stay beneath the water and the length of the intervening rests their actual working time is short.

This method of sponging is followed to best advantage on uneven bottom too rough for the dredge, where the sponges are in crevices or under overhanging ledges which make them invisible to the harpooners or where the rocks are so sharp as to make the use of the scaphander dangerous, owing to the liability of injury to the suit and hose. Most of the finest "cave" sponges of the Ægean are taken by this means.

Nude diving is carried on from small boats, the crews of which are generally paid wages, while the diver works on shares. On the African coast this fishery is carried on during the fall and early winter, when the bottom is comparatively free from marine vegetation, but in the Ægean and the Levant it is conducted during the warmer months of the year.

Harpooning.—This, historically the third method of sponging, has been used in the Mediterranean for many years and is still employed on practically all of the sponging grounds where the water is not too deep. It is practically the same in its general features as the hooking on the Florida coast, and the conditions of wind and weather necessary for its success are the same. The instrument employed is essentially a trident, though it may have other than three barbed points or tines. The Tunisian fouchga has two barbed points, the Sicilian fuscina, fuscia, or fiocino has three points, the Greek kamaki has four, while the Dalmatians use a five-pointed instrument. These all differ from the hooks of Florida and the Bahamas in having the tines straight instead of recurved.

The water telescope, practically similar to that used in Florida and the Bahamas, is now generally employed in all parts of the Mediterranean, but it was not used on the African coast until introduced by the Greeks about 1875.

The boats employed are various, each nationality having its preference, those of the Sicilians resembling New England dories; but they are all small, and are manned by two or sometimes three men, one of whom is the harpooner. The boats used by the Greek harpooners are similar in shape to the diving boats elsewhere described. The harpooner stands in a small circular hatch forward and, with a cushion placed beneath his chest, leans over the bow to scan the bottom through his water glass. The nomadic Greeks and Sicilians use large living and deposit boats, while the native spongers of the various regions have

smaller, less seaworthy vessels, or dispense with them entirely when working near home. The working boats, corresponding to the dingeys of the Florida coast, are propelled usually by one, occasionally by two, pairs of oars, and are not sculled with a single oar as in our own waters. When a sponge is sighted the harpoon is driven into it, preferably on the side near the root, and it is detached by a double motion of rotation and rocking.

This fishery is practicable in deeper waters than those in which hooking is carried on in Florida. Depths of even 70 to 80 feet are reached, and off Benghazi sponges are harpooned in as much as 90 feet. In fishing in such deep water three persons are assigned to a boat, the third usually a boy handing the harpoons to the harpooner and assisting in attaching and detaching the additional shafts.

The poles are about 20 feet long, and to the top of each is lashed a short stick, about 6 or 8 inches long, the end of the pole being slightly cut away to create a space between it and the stick. Into this gap the end of the next harpoon is thrust and held in place by a ring, just above the iron, which is slipped over the stick. A third, or as many harpoons as are necessary, are added to reach the desired depth. After the sponge is impaled and torn loose from the bottom the poles are successively detached as they are brought up. The sponges are less firmly attached to the bottom than are those of Florida.

Owing to the rents likely to be made by the harpoon, the finer grades of sponges are less valuable when taken by this method than when procured by diving, and are known in the markets as "harpoonées," as distinguished from "plongées." On the Tunisian coast there appears to be but little difference between the two in price. In Dalmatia tongs are employed, one leg of which is attached to a pole and the other operated by a cord.

Dredging or trawling.—The dredge or trawl (Greek gangava, Italian gagova or cava, French drague), shown in text figures 2 to 4, is of special type and large size, and has been used for many years by Greeks in the Levant and by Greeks, Sicilians, Neapolitans, and Maltese on the coasts of Africa and the banks of Lampedusa. It consists, essentially, of a rectangular frame from 15 to 40 feet long and from 20 to 30 inches high, to which is attached a bag about 6 to 10 feet deep, made of large-mesh webbing of light rope (fig. 2, p. 487).

That part of the frame which scrapes the bottom is a round iron bar about 2½ to 3 inches in diameter, the ends being bent at right angles for a distance equal to the desired height of the frame and connected by a stout wooden bar to form the top. Frequently the ends of the frame are short wooden bars fitted into sockets in the upturned ends of the iron bar (fig. 3, p. 488).

In the larger frames the parallel iron and wooden bars forming the bottom and the top of the frame, respectively, are connected and stiffened by one or two transverse struts (fig. 4, p. 488), but in the smaller dredges these are omitted.

The bridle is composed of a rope running from the middle of the wooden top bar and two, three, or four chains connected near the ends and at one or two intermediate places on the bottom bar, all being united in an eye or ring to which the towrope is attached. The several parts of the bridle are of such comparative length that the frame stands upright when towing. The net bag is laced to the wooden top bar and to rings welded to the iron part of the frame. The tow rope or cable varies in length from 300 to 600 feet, and passing through a chuck or snatch block near the bow is led aft to a hand wind-

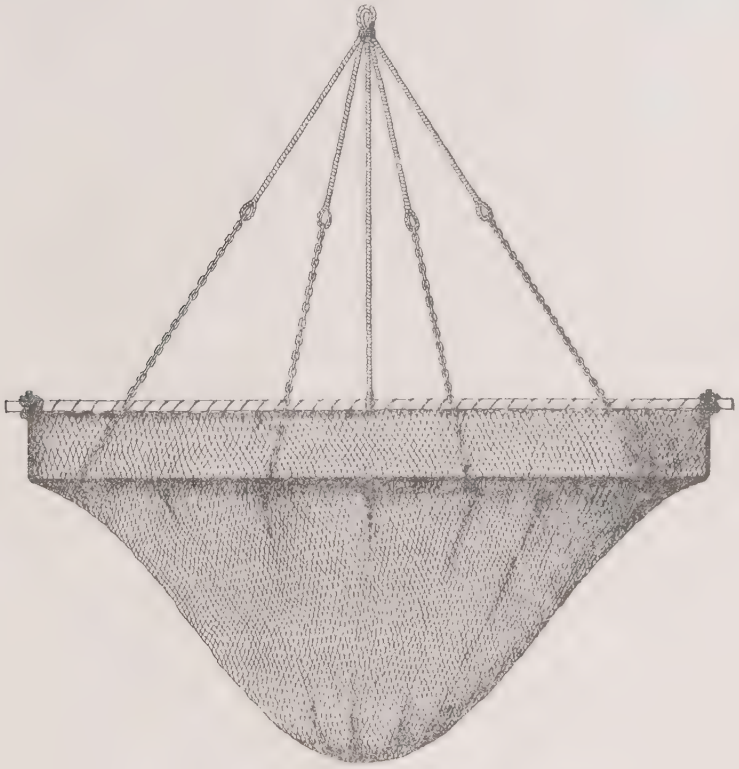

FIG. 2.—Dredge, or gangava, used in Mediterranean sponge fisheries.

lass. A guy line bent to the cable with a rolling hitch at some distance from the vessel is led directly to a cleat or bit near the stern, and is used in controlling the drift of the vessel. A similar line is carried under the jibboom and attached to the opposite side, to be used when the vessel comes about.

The method of using the dredge is essentially as follows: By means of masthead tackles or davit tackles attached to the wooden bar of the frame it is lowered bag first until the frame reaches the level of the rail. The towline is then bent to the bridle cringle and carried through a snatch block forward. The tackles are cast loose and the net lowered by slowly paying out the tow line

until the bottom is reached, when paying out ceases for a moment to allow the bag to straighten out without fouling the frame or bridles. The weight of the chains and the lower part of the frame and the buoyancy of the wooden upper bar makes it easy to land the apparatus right side up. The towline is then paid out with a scope commensurate with the strength of the wind, less being required in light and more in strong breezes, and the guy lines are bent on at such distance from the ship as to give proper facility in handling.

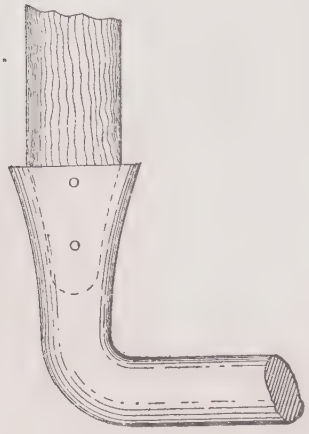

FIG. 3.—Section of dredge, frame showing bend of iron bar at ends.

The apparatus is always paid out on the windward side, the vessel drifting to leeward with comparatively slight headway, so as to drag the dredge at a speed of about one mile per hour. The guy line is used to govern the boat's position with respect to the dredge and the wind so as to secure the proper direction and speed of drift. Slacking the line puts the boat closer to the wind, decreasing both speed and headway, while hauling it in puts her off the wind, thereby increasing both headway and drift.

Should the direction of drift carry the dredge off the edge of the sponge bed, the weather guy line is slacked, the vessel comes into the wind, the lee guy is hauled in, the towline is passed under the bowsprit and made fast on the other bow, while the vessel pays off on the opposite tack across the bed.

When the dredge is full, the fact is indicated by the heavy drag of the apparatus. The headsails are then lowered and the guy line is paid out until the vessel is head to the wind. The towline is passed to a snatch block forward and is hove in until the bridles come home to the block. Two rather long flying bridle lines, not shown in the drawing, are then hooked to masthead tackles, or usually to a pair of davits, and are hove in by small hand windlasses until the iron bar is brought level with the rail, where it is secured by a couple of chain stops. The contents of the bag are then overhauled, the rubbish thrown overboard, and the sponges on deck. Three men can handle the vessel and dredge, but as the work is carried on day and night the crew generally consists of 5 or 6.

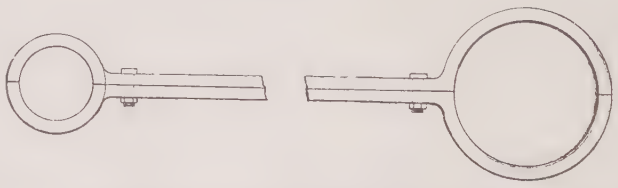

FIG. 4.—Transverse struts sometimes used between bars of dredge frame.

This apparatus can be employed on smooth bottom only, as the frame is liable to foul and the net to be torn on rough rocks, but it can be used at all seasons of the year and in all ordinary weather. It is much complained of for its destruc-

tiveness, the charge being made, apparently with justice, that it tears loose or crushes all sponges in its path, both large and small, and that not only is a considerable portion of the catch inferior on account of the small size, but that many sponges are torn loose and not brought up at all, being left to die on the bottom or to become rollers. In some localities the gangava is prohibited in depths less than a prescribed minimum. In Egypt the limit is fixed at 80 meters (262 feet), and in Cyprus the instrument is entirely prohibited. It is used principally on the African coast and on the banks of Lampedusa.

There are probably between 400 and 500 dredges or gangavas employed in the sponge fisheries of the Mediterranean, of which the great majority come from the Sporades and Cyclades.

Machine diving.—This method of diving and the apparatus employed is sufficiently described in that part of this paper treating of the Florida fisheries. The scaphander was introduced into the Ægean and the Levant about 1866, and at once came into such general use among the Greeks that ten years later about 110 machines were in active service. In 1907 it was reported that there were from 100 to 120 diving machines for sponge fishing owned in Greece alone. In 1903 there were 158 diving outfits employed in sponging under the Greek flag, the reduction in 1907 being probably due, at least in part, to the export of apparatus to the United States for use in Florida.

From the time of its introduction the diving dress has met with active and sometimes violent opposition from the spongers using the older methods, who charged it with being destructive to the sponge beds. Recently it has been opposed on hygienic grounds, and, mainly through the efforts of Mr. Charles Flegel, since 1892 its use has been prohibited in Austria-Hungary, Egypt, Crete, and Samos. Turkey also passed prohibitive laws, but they were not enforced and have been repealed, and the interdiction formerly existing in Cyprus has been removed. Italy and Greece have placed restrictions on the depth to which the divers may go, and both have vessels to enforce the law, which, however, is more or less generally ignored. The Greek regulations prohibit all diving at greater depths than 127 feet, and at least until recently regulated the period for which the diver could remain submerged at various depths. During the sponging season the Greek Government maintains a hospital and hospital ship on the African coast to provide medical attention and succor to the divers.

Some divers are injured or killed by accidents to the diving dress or hose, but the chief danger to which they are exposed is caisson disease, which is a frequent consequence of working in depths of over 60 feet. This malady is caused by the absorption of gases from the compressed air and their release as bubbles in the blood vessels and tissues upon decompression, especially if the latter be rapid, as in the quick ascent of a diver from the bottom. In caisson

work rapid decompression is guarded against by gradual transition from higher to lower compressions in the air locks, or in carefully regulated diving with the scaphander by slow ascents, but in sponge diving these precautions are ignored, with the result that many of the divers become paralyzed and a considerable number of them are killed. Flegel states that the average yearly mortality among the Mediterranean divers reaches the almost incredible proportion of nearly 20 per cent, and the cases of more or less serious illness about 25 per cent. He states, further, that during thirty-nine years upward of 5,100 sponge divers were killed by their work and 2,100 were so paralyzed as to be incapacitated.

That the results of sponge diving are so serious is not surprising in view of the practices obtaining. I am informed by various authorities that the machine divers in the Mediterranean go to a depth of 250 feet, remaining on the bottom three or four minutes at each descent. Boats working in these depths carry 12 or 13 divers, each of whom has a rest of about two hours between plunges. Though the pressures are so great that the heavy woolen stockings worn by the divers are pressed deeply into the flesh, no measures are taken to ascend gradually, the claim being made that the more quickly the person is removed the less the liability to injury. Sponge divers have informed me that serious cases of "bends" occur more frequently in depths less than 25 fathoms than in those greater, owing to the shorter time to which the diver is subjected to the pressure in the latter case.

On the other hand the highest scientific authorities on diving place the safe limit for physically sound men at 150 feet, and they all prescribe a slow ascent and a gradual release from pressure as an essential element of safety. In caisson operations, where the conditions under which the men are working are essentially the same as those in a diving dress, the compulsory use of air locks for gradually reducing the pressure on workers making the exit has been found absolutely necessary to preserve the health of the workmen. It appears that the incentive to deep diving is imposed largely by the financial conditions under which the fishery is conducted. The masters of the vessels, having little capital, are obliged to borrow at rates as high as 25 per cent, and feel obliged to force their divers in order to make their ventures pay.

In many parts of the Mediterranean the sponges grow on bottoms covered with vegetation, the location being often indicated by a mere hiatus in the tops of the growth. In working on such bottom the diver lies almost horizontally above the vegetation, looking for the telltale spots and locating the sponges by feeling with his hands.

About the islands of the Ægean many sponges are attached to the faces of submarine cliffs 50 or 60 feet high, and to reach them the diver floats himself by regulating the air pressure in his suit and propels himself from place to place by a swimming motion of the hands.

The scaphander fishery is mainly in the hands of Greeks from both the Grecian and Turkish islands, and there were recently between 250 and 300 diving outfits in use in the sponge fisheries of the Mediterranean.

Cleaning and curing.—The native fishermen of Tunis sell their product in the natural state, but all of the other spongers of the Mediterranean cure their catch before selling it. The process of curing is essentially that followed by the Greek divers in Florida which has already been described. The sponges sold by weight are loaded with sand, marble dust, and other materials. They are packed under foot in cylindrical bales weighing from 40 to 75 pounds, or in boxes. A considerable proportion of the Mediterranean sponges are bleached before entering the final markets, the process being essentially that employed in the United States and elsewhere described.

VII. VARIOUS MINOR LOCALITIES.

Sponges of some economic value are found at various places which have not yet developed fisheries of commercial importance. In other localities sponges closely allied to economic species or zoologically identical with them have been recorded by naturalists, though but little is known of their abundance, accessibility, and characteristics as measured by commercial standards. Certain of these places geographically adjacent to the important sponge fisheries of North American and the Mediterranean have been discussed, but the isolated localities can be considered most conveniently in a separate chapter. Certain of them are quite likely to develop, eventually, fisheries of more or less importance, especially with the growth of a demand for sponges incident to the extension of modern civilization and manufactures.

PHILIPPINE ISLANDS.

When this archipelago has been more thoroughly explored and its marine resources are more generally known it is probable that it will support a sponge fishery of some importance. The recent work of the Bureau of Fisheries steamer *Albatross*, not yet concluded, has brought to light several sponges of commercial utility, though of rather poor quality.

The Tawi-tawi group appears to be particularly rich in horny sponges, some of which are of value commercially, and the *Albatross* obtained specimens at Siminor, Tataan, and other localities. Small grass sponges were found in extraordinary abundance on the tide flats of Tataan Island, attached to the coralline and shelly bottom in a depth of 1 to 1½ feet at low water. Several other kinds of possible value are reported from the same locality.

Similar sponges are found at Siassi in the Tapul group and several Americans have recently gone into the business of gathering them for the market. Inexperience in curing and packing lessened the value of the product, but it is under-

stood that instructions given by the *Albatross* party have resulted in improvement in this respect.

About the island of Sitanki or Sibutu there are considerable beds of sponges resembling somewhat the toilet sponge of the Mediterranean, though with the upper surface more fibrous and with numerous closely ranged pores. The sponge is very soft, but much weaker in fiber than its Mediterranean congener. Thirty or forty thousand of these have been marketed in Singapore and shipped to New York and London, where they brought a low price.

On the south side of Jolo the *Albatross* obtained a single beach-worn specimen closely resembling the reef sponge of North American waters. From the north side of the same island there was collected, in a depth of 20 fathoms, a specimen resembling the elephant-ear sponge, very strong but harsh and rather incompressible. The texture is closer and more dense than in the Mediterranean sponge and the primary fibers of the skeleton are so heavily laden with sand granules as to render it of but little commercial value. It is possible that superior qualities may be found in other localities. The specimen collected is about 15 inches in diameter, almost flat, with several flaps or lamellæ on the upper surface, and was attached by a short stalk or peduncle.

Small sponges said to resemble the Key grass of Florida are sold in the shops of Cebú and are reported to come from nearby reefs. Others of excellent quality resembling wool and yellow sponges are sold in native shops in various places but are believed to be imported. I have been shown a specimen, said to be indigenous, which very closely resembled the Bahama sheepswool. It had apparently been in use for bath purposes and I am convinced that it was exotic. Another specimen from an unknown locality was of excellent shape and quality, somewhat resembling the honeycomb sponge of the Mediterranean but differing from it sufficiently to remove suspicion that it was not of native origin. It was soft, strong, firm, and elastic, rather flat and attached by a narrow base. If it can be obtained in quantities, it should prove of considerable commercial value.

AUSTRALIA AND NEW ZEALAND.

The sponge fauna of Australia is exceedingly rich, and according to Lendenfeld the zoological species which include the elephant ear, honeycomb, zimocca, glove, and reef sponges are found on its coasts, in addition to several others which he regards as of possible commercial value. The rather poor specimens of Australian sponges which I have examined, comprising 10 or 15 species of supposed commercial value, were nearly all of inferior quality, open in texture, irregular, hard, and harsh. The specimens had the appearance of being beach worn, and the defects of some of them were due in part to imperfect curing. One or two kinds could probably find a limited market at a low price. Attempts have recently been made to find a market for these sponges with a

view to establishing a fishery, but it is understood that the results have not been encouraging. Honeycomb and reef sponges are reported to occur in New Zealand.

OTHER PACIFIC OCEAN LOCALITIES.

The horny sponges of the Pacific islands are known practically from the *Challenger* collections only, those of the various expeditions of the *Albatross* not having been studied.

In the Sandwich Islands there occurs a sponge which somewhat resembles the sheepswool in appearance, but the single specimen upon which the report is based was hard, very weak of texture, and of little, if any, commercial value. A reef sponge from the Fiji Islands and a grass sponge from the Gilberts, both of doubtful value, practically complete the record for this region, although the Carolines are stated to produce a soft, fine sponge, probably not unlike the Sitanki sponges of the Philippines.

INDIAN OCEAN.

I have recently received inquiries in regard to a toilet sponge from the coast of Madagascar. It is stated to "look like the Mandruka toilet sponge," but to have a poor texture and to be lacking in durability. This is possibly the sponge which Cotte says is taken at the southern end of the island about Cape St. Marie. The American consul at Tamatave in response to inquiries reports that sponges occur on the west of the island from Cape St. Marie to Ambohibe, a distance of 340 miles. About 1902 5 Greek divers were employed by 2 merchants and in 1907 some Ceylonese were employed by another concessionaire, but both experiments proved failures and excepting a few sponges taken by natives there is at present no fishery. The price received by native fishermen is about $1.15 per hundred pieces, the sponges being very badly cured. None were exported in 1908.

Lendenfeld records several varieties of the common toilet sponge, the velvet, and several other species of horny sponges from Mauritius, but nothing is known of their economic value.

Sponges also occur in the Seychelles, and the government of those islands has recently taken steps to determine their commercial value.

In Ceylon a variety of the toilet sponge is found in abundance, and Hornell believes it to be of commercial value. *Euspongia irregularis pertusa*, which includes the yellow sponge of the Gulf of Mexico, is also recorded from the island, but nothing is known as to its commercial characteristics and value.

MID-ATLANTIC OCEAN.

Weil states that there are beds of excellent sponges lying in deep water about the Cape Verde Islands and the Azores, and that in quality and general characteristics they are intermediate between those of the Mediterranean and

western Atlantic. He believes that in those places a profitable fishery merely awaits the time when the exhaustion of the older fisheries will force their exploitation.

I have been informed by a Greek of wide experience on both sides of the Atlantic that in the shallow waters about the Canary Islands there is a sponge closely resembling the coarser qualities of the yellow sponge, though the shape is flatter.

Several sponges are reported from the Madeiras and the Bermudas, those of the latter islands resembling those of the North American coast and including the grass, sheepswool, and possibly the velvet. The velvet sponge is also recorded from Fernando de Noronha, off the Brazilian coast, indicating the probable extension of the American commercial sponges along the mainland south of the equator.

VIII. CONDITIONS AND EFFECTS OF THE SPONGE FISHERIES.

DEPLETION OF THE BEDS.

Wherever the sponge fisheries have been prosecuted with vigor for a long period, there has resulted a more or less definite depletion of the beds, or a well-grounded fear of the approach of that condition. The commercial sponges can never be actually exterminated by the agency of man. It is an impossibility to denude the grounds so completely as to leave none for reproduction, and, moreover, as soon as the beds become so depleted as to reduce the earnings of the spongers to a bare living wage, the economic result is a reduction in the number of fishers and the establishment of an approximate equilibrium between productiveness and catch. The point at which this equilibrium is established will vary with economic conditions, becoming lower with an increase in the value of the product and higher with an increase in the cost of living of the fishermen. More men, gathering in the aggregate a somewhat larger quantity of sponges, though the catch of each individual may be less, can be supported when the price is high than when it is low, and this results in increasing the fishery, in a further reduction in the productiveness of the beds, in profits, and eventually in the number of fishermen, the equilibrium being again established on a somewhat lower plane of productiveness. Thus, while the sponges are never actually exterminated there results an approximate commercial extermination, never quite complete for the reason that were the fishery entirely abandoned the beds would soon recuperate and again become commercially productive.

This is well illustrated in a number of cases. In the Adriatic, sponges were formerly much more abundant, but the fishery has been nearly stationary for a number of years. In the Ægean and on the Syrian coast there is said to have been a material decrease during the past thirty years, but the conditions of the

fishery are such that it is difficult to obtain statistics which will show the actual product of the beds in those waters.

On the African coast the yield of the beds during the past fifteen or twenty years has been fairly maintained, though most writers on the subject have expressed the opinion that the productiveness of the beds is waning, and that the average size of the sponges is growing smaller. Such statistics as I have been able to obtain show a rather remarkable uniformity in the total catch. In the fishery tributary to the Benghazi market the only material variation in the catch between 1889 and 1895 can be traced to a difference in the intensity of the fishery, especially in the number of scaphanders employed. In Tunis during the twenty years between 1885 and 1904 the maximum yield has exceeded the minimum by about 25 per cent, and the catch of 1904 was greater than for any year previously recorded, excepting 1890 and 1894. The average catch of three years prior to 1892 was 216,000 pounds and for five years since that date 224,000 pounds. In this connection it must be noted, however, that between 1890 and 1892, principally in the latter year, there was a rapid increase in the number of fishermen from about 3,000 to about 4,500 with a corresponding increase in the number of boats employed. In other words, if the statistics be reliable, an increase of 4 per cent in the average yield of the fishery has been produced by an increase of about 50 per cent in the number of fishermen. This, possibly, may be accounted for to some extent by changes in regulations or methods of which I am ignorant, but the facts substantiate the statement that the dealers of Sfax and the spongers themselves are of the opinion that the fishery is being depleted, as indicated by the smaller catch per man employed and the increasing proportion of small sponges.

The total product of the banks of Lampedusa has decreased materially since 1888–1899, when the fishery reached a maximum in both yield and intensity. Considered by five-year periods, the available statistics appear to indicate some depletion of the beds during recent years. During five years from 1890 to 1894, inclusive, the average catch per sponger was about 151 pounds, the average of five years from 1895 to 1899, inclusive, was the same, while the average of the four years from 1901 to 1904, inclusive, was but 120 pounds, a decrease of 20 per cent. Owing to the fluctuating proportions of scaphanders and dredges from year to year and other variations in the fishery, it may be that this decrease has no great significance, but those familiar with the beds are of the opinion that their productiveness has decreased. It is noteworthy also that the smallest catches made since 1889 were in the years immediately following the intense fisheries between 1895 and 1900, when the largest number of men and boats were employed and the beds most thoroughly scoured. In the Mediterranean the dredge and the scaphander are both blamed for the depletion of the beds, the former because it tears everything from the bottom and the latter because

of the number of small sponges taken. The harpoon and naked diving are regarded as harmless, and it is generally held that the beds could not be seriously injured by those methods alone.

On the western side of the Atlantic the case is different. In Cuba and the Bahamas, and until recently in the United States, the diving machine has not been used and the dredge is unknown. Hooks, the equivalent of the Mediterranean harpoon, were the only implements employed, yet the complaints of waning productiveness of the sponge grounds are quite as loud and, in some cases at least, as well grounded.

The earlier statistics of the Florida fishery are nearly valueless for the determination of the productiveness of the beds. The sponges are bought by bunches which vary in weight with the size and character of the sponges and the manner in which they are strung, and the only comparative weights or quantities which are available are those of the packed goods. Unfortunately these weights are not those of the pure sponges but of sponges plus salt, sand, glucose, and other materials used in loading. Were this loading uniform the statistics would still be of some value for the purpose of the present inquiry, but the amount of foreign matter introduced has gradually increased since the practice was recommenced, about 1895, after an interval of comparatively honest packing, until in 1903–4 I found it to range between 100 and 150 per cent of the true weight of the sponges. At that time, and until the heavy influx of sponges from diving operations, practically all sheepswool sponges and some of the cheaper grades were heavily loaded, and even much of the small quantity sold as "pure" was more or less "doped" with salt, glucose, glycerin, and a little litharge. Since 1903 the statistical weight of the catch has been based upon an assumed approximate average weight of the bunches and the result is probably more accurate.

Considering the total yield of both Bay and Key grounds, the average catch of sheepswool sponges between 1895 and 1899, inclusive, was 173,043 pounds, while between 1900 and 1904, inclusive, it was 186,155 pounds. In the latter period, however, there were two years, 1901 and 1903, when clear water on certain grounds rarely fished gave the spongers access to practically virgin bottom. It should be stated, however, that in the latter part of this term the number of men and vessels employed exhibited some decrease.

In the period from 1905 to 1908, inclusive, there occurred a great increase in the production, the average product of sheepswool sponges being 313,697 pounds. This was due to the introduction of diving.

Considering the production in its relation to effort expended in the fishery, we find that each man engaged in hooking from 1900 to 1904, inclusive, produced an average of 100 pounds of sheepswool sponges per year as compared with an average of 81 pounds for the years 1905 to 1908, inclusive. The

average production per diving boat per month of actual operation, as nearly as can be ascertained, has been 385 pounds in 1905, 437 pounds in 1906, 338 pounds in 1907, and 206 pounds in 1908. The latter part of 1907 and the entire spring of 1908 was characterized by boisterous weather, and part of the decrease may be due to these conditions.

So far as we can judge from the statistics, however, and making due allowance for the uncertainties of the fishery, there appears to have been a considerable decrease in the productiveness of the beds, especially in the Gulf of Mexico, since 1900, a statement which is strongly supported by the observations of those engaged in the fishery.

HOOKING AND HARPOONING.

Hooking and harpooning are essentially the same and are limited by the same conditions. They can be carried on only when the weather is moderate and the water clear, and as the latter essential may occur on some beds only at intervals of several years, as, for instance, on the New grounds off Cape Sable and in the deeper water on the Bay grounds, there is imposed on these methods of fishery certain natural and irrefrangible close seasons which operate to effectually protect certain beds by restraining the fishery for sufficient periods to permit of recuperation. In most places, however, clear water is the rule rather than the rare exception; and in such cases hooking, while temporarily inhibited, may be carried on for a greater or less part of each year. When this is the case the effects on the beds are dependent upon the intensity of the fishery and the degree to which the fishers rob the grounds of young sponges. As a rule, wherever the beds are sufficiently productive to make it profitable they are worked beyond reasonable limits until more or less gradually the yield is reduced below the economic minimum and most of the spongers withdraw to other fields, leaving, however, enough of their less enterprising fellows to prevent the possibility of effective recuperation. This has been the case on the Key grounds of Florida, where the fishery continues to produce a small crop, though abandoned as unprofitable by most of the vessels and some of the boats. The New grounds, where the water is found clear only at intervals of several years, still produce sponges under favorable conditions, while several other places—for instance, the vicinity of Bamboo Key, which were almost abandoned for a while—have again become moderately productive.

In connection with the hook fishery there are two factors which assist in the recuperation of the beds. One is the presence of sponges in adjoining waters too deep to be reached with the hooks, and the other is the retention on the beds actually fished of sponges which are out of sight from the surface. This is more fully discussed in connection with diving. Another factor assisting in the recuperation of the beds reserved to hookers is the regenerative growth of fragments

remaining attached to the bottom after the main portion of the sponge is torn loose. It often happens that the hooks are inserted above the base, and more or less of the root is left to grow into a new sponge. On overworked beds the spongers frequently find apparently large sponges which are so flat that the hooks can not be inserted at all, and a bed which has been fished continuously for a series of years produces more flat sponges than when first discovered. It is probably because the beds are only worked at intervals of several years that the New ground sponges have a greater height than those from other Key grounds, and the sponges now being taken from the rested Bamboo Key grounds are higher than those formerly obtained. It is not at all unlikely that this regeneration of attached "roots" is a more important factor in the rejuvenation of the beds than is generally supposed.

The greatest abuse connected with hooking is the capture of small sponges, though the proportion of those below the legal limit of 4 inches is smaller than in the catch of the divers. This abuse is always greater on partially depleted grounds, which are less able to stand the drain, than on newer and more productive beds. A gradual reduction of the average size of the individual sponges taken is always a serious symptom of depletion already accomplished and a potent cause of greater depletion to come.

NUDE DIVING.

Nude diving is not practiced to any extent in the fisheries of the western Atlantic, and though it appears less objectionable than almost any other method it is prohibited by the laws of Florida. The natural limitations imposed upon this fishery are stringent and are such as to prevent the depletion of most beds by this method alone. The sea must be moderate and the water fairly clear, while the brevity of the period of submergence and the length of the intervening rests, together with the small proportion of men who will develop into first-class divers, makes the devastation of the beds by such means a remote contingency. Although sponges unattainable by other means can be taken by this, the history of the Mediterranean beds leads to the conclusion that nude diving is comparatively harmless to the sponge grounds.

MACHINE DIVING.

The objections which have been urged against the use of the diving machine are resolvable into essentially two: (1) That the divers with their heavy-mailed shoes crush innumerable young sponges in walking over the bottom, and (2) that they take everything, large and small, leaving the bottom denuded of the growth essential for reproduction.

The first objection appears ridiculous to anyone familiar, either theoretically or practically, with the principles of diving. It is true that the diver as he appears

on the deck of the vessel is burdened until he is hardly able to walk, partly by the essentials of his dress, but largely by weights which he deliberately adds for the express purpose of enabling him to keep on the bottom when submerged. After his descent, when his dress becomes inflated, it is necessary to release air from time to time, not only for purposes of respiration, but to prevent the buoyancy of his inflated suit from raising him to the surface, and should he lose a weight on a shoe he will immediately lose control of himself and float. It is one of the well-known restrictions of working in the diving dress that while a strong upward pull can be exerted a vigorous lateral push can be put forth only when the diver can place his foot or some part of his body against a fixed object, while even a moderately effective downward push or blow can not be delivered unless the operator can anchor himself by holding with his hand or other means. These restrictions in the employment of his full strength all result from the lightness with which the diver rests on the bottom, the ponderous and grotesque object which can barely stagger on the deck of the boat treading gently with but a few pounds pressure as he travels over the bottom. As the weight with which the diver actually treads could seriously injure none but the very smallest sponges, and as his footprints can not possibly cover more than a very small proportion of the ground over which he works, this objection to the diving machine can well be totally disregarded.

The second objection stated above is more serious. It has been claimed by some opponents of diving that the diver is unable to distinguish accurately the size of the sponges, owing to the optical conditions under which he works, while the advocates of the method claim that he is in much better position to do so than is the hooker, looking through a deep stratum of water of variable transparency. There is but little doubt that experienced divers, depending not only on eyesight but upon touch, can distinguish with sufficient nicety to avoid flagrant breach of the law and common prudence, but so long as undersized sponges have a market and infractions of the law are not punished they will not hesitate to pluck most of the young sponges which come in their way. Whether they do the damage knowingly or unwittingly is of no material moment, however, in the face of the fact that the damage is done, and there is no doubt that immense numbers of small sponges are brought in by the divers, many of them being sold in the exchange at Tarpon Springs, while undoubtedly a much larger number are shipped for sale in other markets. The proportion of these sponges to the total catch appears to be much larger than among the product of the hookers.

Another phase of this matter is concerned not so much with the taking of the young sponges as with the thoroughness with which the bottom is denuded of all sizes. In working over rough bottom especially, the hookers and harpooners always leave a considerable proportion of the sponges, not from choice but because they are overlooked, hidden from view from above or inaccessible

owing to their situation in crevices or under ledges. These the divers are able to find and obtain and in consequence they leave fewer sponges to furnish the young necessary for the recuperation of the beds. Where the divers are working on grounds already partially depleted by other methods of sponging, as was the case during the first two years of the fishery in the Gulf of Mexico and in many places in the Mediterranean, there can be no doubt that the method is exhausting to the beds, even if it be conducted without the abuse of gathering undersized sponges. When the beds are already worked to or beyond their limits of productiveness any method which increases the draft upon them must be injurious.

This was one of the contentions of the opponents of diving in Florida and was the reason for the restriction of the divers to depths greater than 50 feet. It was hoped by this means to preserve the inshore grounds inviolate for the hookers, while permitting the taking of sponges in the deeper waters unattainable by the methods previously in use. Concerning the productiveness of these offshore grounds we are not yet in possession of data which would warrant an opinion of value, but the little that we do know does not indicate that they are more productive mile for mile than were the shoaler waters when first discovered. In fact, the bars appear to be fewer and more scattered, and though sponges occur on some of them in great numbers, this abundance is due to the fact that they are virgin beds and have never before sustained a fishery. There is no doubt that in time some, at least, of these will be depleted and the proximity of that time will be proportional in some measure to the intensity of the fishery and conversely to the area of new grounds developed.

Assuming that the fishery can be carried on to the 20-fathom curve and that the productiveness of this region is proportionately equal to that covered by the hookers, an increase of from 250 per cent to 275 per cent in the annual product, making no allowance for the consideration about to be presented, would result in approximately the same degree of over-fishing which had gradually decreased the catch of the hookers prior to 1905–6. This allowable increase was nearly attained in the year ending May 1, 1907, when the value of the sheepswool product was over twice the normal of the years immediately preceding. Owing to the sudden increase in the supply the price dropped far below that of previous years.

In discussing the effects of the fishery upon the rate of depletion of the inshore beds, consideration must be given to the effect upon their recuperative powers of the sponges lying in the deeper water, beyond the reach of the hookers but now being taken by diving. Undoubtedly a considerable proportion of the young sponges on any bed are the offspring of breeding adults in the immediate vicinity, either overlooked by the hookers, concealed from sight under ledges, or protected from capture by the prevailing turbidity of the water, all factors

less operative with the divers; but it is equally beyond doubt that no inconsiderable proportion are derived from sponges in deeper water, at a distance from the beds on which the young finally settle.

We have evidence that this must be true in the phenomena of the recuperation of large areas after the practically complete extermination of the sponges from so-called "poison water." This has recurred at irregular intervals about ten years apart. In 1878, for instance, practically all sponges accessible to the hookers between Johns Pass and Cedar Keys were destroyed and the fishery was abandoned for several years, the first sign of recuperation being observed about 1882. About 1895 a similar occurrence in the northern part of the Bay grounds killed the sponges between St. Marks and the mouth of the Suwanee River from about the 5-fathom curve to the greatest depth explored by the hookers, and in 1901 I was informed that the first sponges taken since then from the depleted bed had been obtained recently.

The evidence all indicates that over the large areas involved few if any sponges escaped the disaster, and as the repopulation of the beds was apparent practically simultaneously over the whole area and did not appear first merely at its edges, it is evident that the young must have been derived from grounds more or less remote. The very young sponge is a free-swimming organism which is probably often carried far by currents before it reaches the stage at which it settles down and becomes fixed. It is evident that the rate or probability of recuperation of any exhausted area depends not only on the number of resident breeding sponges, but also upon the presence and number of such sponges on surrounding areas. An exhausted area adjacent to virgin beds will have a more abundant set of young than if the surrounding areas are equally exhausted. In the history of the sponge grounds of the Gulf of Mexico prior to 1905 there were always untouched bars offshore just beyond reach of the hooks, and these must have supplied untold millions of fry to the workable beds, retarding their commercial exhaustion. This condition is now changing, for the offshore beds themselves are yielding up their sponges in large numbers, and even if they exist in still deeper water than has been explored the virgin beds are becoming more and more remote from inshore waters. It would appear, then, though the basis of the conclusion is purely a priori, that, in view of the increasing exploitation of the deeper beds, the grounds now reserved to the hookers will probably not have the same powers of recuperation in the future as in the past, and that with the same expenditure of effort in the fishery the product of these beds will tend to fall at an increasing rate. The consequence of this will be that the principal seat of the sponge fishery will gradually move into deeper and deeper water until the limit is reached, either by the depth in which it proves practicable to work or by the attainment of the limits of sponge production, which may be fixed by either the depth of water or the absence of suitable bottom.

The introduction of diving came at a time when the older method of sponging had finally demonstrated its inadequacy to supply the demand for sponges, and by developing new beds it has deferred the time when the Florida sponge beds will no longer be able to sustain the demands of the markets. On the other hand, it will undoubtedly operate to retard the recuperation of beds already or about to become exhausted, and will, of itself, tend to depopulate the beds on which it is carried on and, indirectly, the hooking grounds adjacent to such beds. From the comparative facility with which it can be conducted, irrespective of the condition of the water, the thoroughness with which the bottom can be scoured and the reckless disregard of the future with which the divers gather small sponges, diving is undoubtedly more dangerous in the denudation of the beds than is hooking. The recent legal restriction of the fishery to the deeper waters and to the more boisterous season of the year, when many days are lost on account of stormy weather, will operate to curtail the catch and the profits and restrict the number of persons engaging in it, and to this extent the conservation of the beds will be accomplished. What may be the ultimate result of the introduction of the diving machine will depend largely upon the area and productiveness of the beds outside of the 8-fathom curve. If they be four or five times as great as those of the beds within that limit, the Bay grounds can support a profitable fishery for some years to come, but if they are no greater than there is now reason to suppose, the effects of the fishery will become apparent within the next five years.

DREDGING OR TRAWLING.

The dredge or gangava is not used in Florida or the West Indies, but the testimony of European authorities and an appreciation of the effects of the dredge and beam trawl used by naturalists indicate that without regulation its effects must be disastrous. If used in profound depths to take sponges wholly beyond the reach of other methods of the fishery it has some justification, but even then it would probably retard the recuperation of the adjoining beds in more shallow water in the same manner as denudation by the scaphander would curtail the supply of young sponges on still shallower beds.

There can be no doubt that the gangava is a destructive engine. With it there can be not even such imperfect selection as is exercised by the hooker and the diver, and the proportion of young sponges brought up is correspondingly greater. On the banks of Lampedusa, where the gangava and the scaphander work practically side by side, it is stated on the authority of Lucifero that the refuse sponges brought up by the former constitute 25 per cent of the total catch, while but 6 per cent of the diver's catch is composed of refuse, small, and seconds. It is stated, also, by the same authority, that owing to the damage done to small sponges it requires five years for banks to recover from the effects of dredging, and even then the crop is limited, while two years suffices for the

recuperation of beds exhausted by diving, and the crop then produced is comparatively abundant. While the hardships and personal risks of the dredgers are negligible as compared with those attending diving, the effects on the beds are far more disastrous.

Owing to the comparatively small expense for equipment and operation, and the fact that dredging can be carried on in all depths and in weather which would inhibit other methods of fishing, it is possible by this means to conduct a fishery of great intensity and to exploit grounds so depleted as to be unprofitable for diving. It is by no means certain that the offshore grounds of Florida are not too rough for the gangava, but to prevent the introduction of this method of fishing in shallow water and to forestall the establishment of a "vested interest" which might be difficult to deal with in the future, it is desirable that legislation be passed restricting the use of the dredge to depths far beyond those which it is possible to exploit by other means.

IX. THE REGULATION AND PROTECTION OF THE SPONGE FISHERIES, WITH PARTICULAR REFERENCE TO FLORIDA.

MEASURES IN FORCE.

Until recently the regulation of the sponge fisheries of the Mediterranean has been, with few exceptions, concerned chiefly with the production of a revenue for the governments concerned, but during the past fifteen years, owing chiefly to the efforts of Mr. Charles Flegel, another element has been introduced, the protection of the spongers themselves from the physical effects of their calling.

It is true that in a few places measures are in force which tend to protect and conserve the sponge beds. In Dalmatia recent attempts to introduce the scaphander and the dredge have met with opposition and interdiction, and the sponge banks are opened to the other spongers only during alternating periods of two years. A somewhat similar regulation is proposed for the Bay of Taranto. In Cyprus the dredge is entirely prohibited, and in Egypt its use is authorized only in depths greater than 262 feet, where it is impossible to take sponges by any other means. In Greece, Tripoli, Tunis, and on the banks of Lampedusa all forms of apparatus are permitted under varying conditions as to taxes and licenses; but in Turkey, Egypt, Crete, and the principality of Samos the scaphander is prohibited on broad economic and humanitarian grounds rather than for the narrower consideration of the protection of the sponge beds, and for the same reason Greece has attempted to regulate the maximum depth to which this apparatus may be used without restricting in any way its employment in shoaler waters, in which it might be supposed to do greater damage to the beds. The attitude of the Greeks in this matter is readily understood, for they are dominant in the fishery and most of their diving is carried on in waters away from home.

In Florida, the Bahamas, and Cuba, while the matter of revenue has been by no means overlooked, more consideration has been given to questions of conservation of the fisheries, the measures adopted being the prohibition or restriction of the use of supposedly destructive forms of apparatus, the establishment of close seasons, and a minimum size of sponges which it is permissible to take.

In the Bahamas, Cuba, and the territorial waters of Florida both the scaphander and the dredge are absolutely prohibited, Florida also including in the interdiction all methods of diving, either with or without apparatus. In Cuba the sponge beds are all in territorial waters, and as the Bahama government without challenge assumes jurisdiction over the entire area of the banks, neither of these countries has much difficulty in making the legislation effective. In Florida, however, a difficulty confronts those interested in the conservation of the industry.

On the Bay grounds in the Gulf of Mexico practically the entire sponge-bearing bottom is outside of territorial jurisdiction, beyond the 3-mile limit, and therefore in neutral waters not subject to direct regulation of either state or national government. So far as this region is concerned, therefore, the laws of Florida are from the nature of the case inoperative, and to obviate the difficulty the Congress of the United States has recently enacted laws prohibiting the landing of sponges taken by diving between May 1 and October 1, those taken by diving at any time in water less than 50 feet in depth, and all sponges of less than 4 inches in their largest diameter taken by whatever means.

The effect of the federal laws, taken in conjunction with those of the state, is, therefore, to prohibit the landing or sale of sponges having a maximum diameter of less than 4 inches; to prohibit naked or skin diving and the use of the scaphander by American vessels fishing for the American market in depths less than 50 feet, and in any depth during the seven months from May 1 to October 1; and to prohibit the use of dredges on the Bay grounds within 3 miles of shore, where there are no sponges, while permitting their use outside of that limit, where the sponges actually exist. No legal restriction is imposed on hooking excepting that applying to the minimum size of sponges which may be caught, landed, or offered for sale. There is no prohibition, nor from the nature of the case does such prohibition appear possible, against either American or foreign vessels using the scaphander at any time anywhere outside of the 3-mile limit, provided that the product of such operations be not landed in an American port except by regular entry and payment of duty as a foreign product.

On the Key grounds these difficulties are not encountered. The waters are shoal. The sponge beds are within territorial limits and under state control, and the federal statutes therefore do not apply and are not necessary.

MEASURES PROPOSED.

The possible measures for the regulation and conservation of the sponge fisheries resolve themselves into (1) the prohibition of taking sponges below a given minimum size, (2) the establishment of close seasons, (3) the restriction of the character, amount, and location of the apparatus employed, and (4) sponge culture. As has been previously indicated, the taking of young sponges is one of the great abuses of all sponge fisheries, and that one most fatal to the perpetuation of the beds; and young sponges are taken by all present methods of fishing, though to varying degrees. A few of them are thrown away by the fishermen, but the vast majority are placed on the market. I have seen 30,000 small sheepswool sponges in the house of one dealer at Tarpon Springs, who paid but $500 or $600 for the lot, an average of less than 2 cents apiece. This was probably the largest quantity bought by any one man at that place, but the other dealers also had large numbers, and it is notorious that the divers ship many away for sale in other places. It is impossible to state the total number of young Florida sponges annually placed on the market, but there must be at least between 150,000 to 200,000 pieces. Accepting the lower estimate, these are worth to the spongers not over $3,000, but if left to grow for another year they would more than double in weight and increase about ten times in value at the present prices. Not only is there this direct monetary loss to the fishery, but there is an indirect loss to the beds resulting from the unprofitable removal of this large number of breeding individuals capable of furnishing fry for the regeneration of the sponging grounds.

The present minimum limit placed on sponges by both the federal and state statutes applicable to Florida waters is 4 inches in the longest diameter when wet, but most persons do not realize the small size of such sponges. The dealer mentioned above was of the belief that all of his 30,000 small sponges were under the legal limit, but a careful measurement showed that probably 50 per cent of them could be construed as complying with the conditions of law, the largest diameter reaching 4 inches, though the other dimensions were usually considerably less. The average weight of such sponges when pure and perfectly dry is less than one-half ounce and they are of little value in the markets. To sell most of them at all it is necessary to bleach them and place the price so low as to leave little profit. If the law is to be made really effective for the protection of the beds and to prevent the taking of economically unremunerative sizes the minimum limit must be raised to 5 inches and the law must be rigorously enforced against spongers, buyers, dealers, and others who are concerned in its infraction. It is believed that most of the buyers and vessel owners at least would welcome more rigorous measures, which would work no hardship to any-

body if enforced on all without prejudice or favor. The difficulty now is that each man feels that the law will be broken with impunity by some of his competitors and that he may as well get his share of such profits as may accrue from disregard of the regulations.

The amendment and enforcement of the law as suggested will not restore the depleted beds to their pristine productiveness nor prevent the partial depletion of beds at present more or less unimpaired, but it will prevent the ultimate commercial extinction of the sponges and will insure for all years to come at least a partial crop from all beds now known or which may be hereafter discovered. As to the foregoing there can be no room for discussion among fair-minded and disinterested persons, but in regard to close seasons the various suggestions that have been made from time to time are open to more or less difference of opinion. The following propositions all have their advocates: (1) The closure of all beds during the spawning season, (2) the closure of all beds for a part of each year irrespective of the spawning season, and (3) the alternating or rotative closure of some of the beds for a longer period while all other grounds are open to more or less unrestricted fishing.

The first suggestion appears to me to be futile and ineffective. In the first place a difficulty presents itself from the circumstance that the sponge, at least in the warmer waters, spawns more or less generally throughout the year, though the greater number of embryos are emitted during spring and early summer. This, however, would be a minor consideration if much were to be gained, for the period selected for closure could be made to correspond with the time of maximum discharge of young, but nothing more would be accomplished than by closing the beds for an equal period at any other season of the year. Whether a breeding sponge is taken before or during the spawning season the loss is the same so far as its potential powers of reproduction are concerned.

The close season embracing a part of each year, similar to that established for the scaphander in Florida from May 1 to October 1, or the Tunisian regulations of like import, is of value chiefly in restricting the catch and leaving a larger number of sponges on the beds. If by an increase in the intensity of the fishery as many sponges are taken in the shorter period as would otherwise be caught in the entire year, practically nothing is gained, for the duration of closure is too short to permit the protected sponges to increase very materially in size and, as stated above, the protection of spawning as distinguished from nonspawning mature individuals is immaterial. Where, as in Florida, the open period is made to coincide with the season under which the fishery is most subject to difficulty and interruption, the regulation is made more effective in protecting the beds by a reduction in the profitableness of the operations and the consequent discouragement of increases in apparatus, personnel, and intensity of the fishery.

A somewhat different aspect is presented by the proposition to close the grounds in rotation for periods of a year or upward. This would tend to intensify the fishery on the open grounds but would compensate for this by providing periods of rest, recuperation, and growth. By periodically closing a portion of the grounds for terms of say two years, there would be given to many of the small sponges already set an opportunity to grow to marketable size, the sponges already marketable would increase very materially in size, weight, and value, and these two would in turn result in the production of a larger number of embryos and a heavier set of young. Notwithstanding that many of the spongers and others interested in the business believe to the contrary, a period of two years is not sufficient to produce a merchantable sponge from the egg, and the earlier set of the closed period would not be ready to market until a year or two after the area was again opened to fishing. Even upon the impossible assumption that all marketable sponges were removed during the first open year, if the young were properly protected in accordance with previous suggestions the good effects of the closure would be apparent over a term of several years.

The practical impediments to the application of this system of protection to the waters of Florida lie mainly in the necessity for making the required subdivisions of the grounds rather small and generally distributed, and the consequent difficulty in securing its enforcement. It would not be feasible, for instance, to close the Bay grounds north of Cedar Keys and open them south of that place for the reason that the water might be turbid in the latter area while clear in the former, to the utter prostration of the fishery and the ruin of those engaged in it. To guard against such contingency it would be necessary to divide the whole area into transverse strips, say 10 miles wide, closing alternate zones or every third zone, as the case might require, leaving the others open. It would be necessary to mark these areas adequately with buoys and to establish a patrol to enforce respect for the regulations. Moreover, as most of these waters are outside of marine jurisdiction, it would appear possible to make the regulations effective to our own fishermen only, though the distance from foreign ports would probably act as a geographical deterrent to the depredations of foreign vessels. In any event the regulations would be difficult to enforce even with the assistance of several guard boats. This is probably the best and most effective type of close season, though presenting practical difficulties of enforcement; but it also is in essence a restriction on the intensity of the fishery and consequently on the yield, and whether it would add materially to the productiveness of the long-used hooking grounds is a matter of grave doubt; however, it might operate as insurance against ultimate depletion. It is practically the method which nature already enforces in places by prolonged periods

of turbid water, the effectiveness of which we can determine by a comparison of the present condition of the grounds with their past.

Restrictions upon the character, amount, and location of apparatus and methods are designed either to suppress destructive or wasteful fisheries or to curtail the use of efficient methods which are not inherently destructive or wasteful, though they may become so in the employ of the reckless or unprincipled. Examples of the first type of legislation are seen in the prohibition of the use of the dredge in Florida, the Bahamas, Cuba, and Cyprus and its restriction to great depths off the Egyptian coast. There is no doubt that such regulation is in the interests of the fisheries. The dredge has no place in a well-regulated fishery in depths approaching those that can be exploited by other means. It may be effective, but it is also inordinately destructive, and the sponge fisheries of this day are in no condition to support unnecessary and preventable waste.

The federal and state legislation restricting the use of the diving machine to depths of not less than 50 feet is an example of the second type of restriction of apparatus. Properly conducted diving is inherently neither destructive nor wasteful. Its chief menace to the beds, if the taking of young sponges be prevented, lies in its efficiency and the thoroughness with which it operates to denude them. It is intense in its effect, and the legislation directed at it is intended to confine and limit it and to preserve both the inshore and offshore beds by practically restricting its efficiency and the volume of its catch. The restriction of the scaphander to water deeper than 50 feet is absolutely necessary for the conservation of the beds already shrinking under the operations of the hookers. Later it may be necessary to protect the divers from themselves and fix a maximum depth beyond which they may not go.

The three general means of regulating and conserving the sponge fisheries above discussed are applicable to the public beds, limiting the intensity of the fishery, aiming to secure and maintain what we have rather than hoping to add to it. They are restrictive and conservative rather than constructive, and without the discovery of new grounds offer little hope of maintaining the supply in equilibrium with the constantly growing demand.

The fourth method, sponge culture, is on the contrary concerned with the sponge industry rather than the sponge beds. It is constructive, aiming to add to the sponge supply of the future without particular regard to the source of supply of the present. It apparently offers the only hope of permanently maintaining the sponge fisheries in those countries in which they are now established, though the discovery of extensive beds in other parts of the world may make it not absolutely necessary for the prevention of an ultimate sponge famine. As it is at present not applicable to the public beds, but even more than oyster culture susceptible of development by private enterprise only, discussion of it is reserved for another paper.

X. CONCLUSIONS AND RECOMMENDATIONS AS TO THE FLORIDA SPONGE FISHERY.

All known and exploited sponge beds, in whatever part of the world, are showing more or less marked indications of depletion, and in some places, notably the Key grounds and to a less extent the Bay grounds of Florida, there has been under average conditions a conspicuous falling off in the product. By the introduction of improved methods of fishing the yield has been temporarily increased in some places, but there is no reason for believing that these increases can be indefinitely maintained or materially augmented.

Such depletion as has occurred is in part due to the taking or destruction of small sponges, but is attributable principally to the intensity of the fishery rather than to preventable abuses. The demand for sponges, especially for those which are employed in the arts and industries, is constantly growing. Countries which formerly used practically no sponges develop a demand with the growth of manufactures, and countries which for years have used sponges now require many more than they did a decade or two ago. In 1880 the United States used about $394,000 worth of sponges and in 1900 about $987,689 worth. In the fiscal year 1907, with a domestic crop of $854,583, imports of $488,426, and exports of $247,145, the apparent consumption was $1,095,864, but of these a considerable quantity were in the warehouses of the dealers at the end of the year. The increase noted is due in part to higher prices but largely to greater consumption. The demand is outrunning the supply and to satisfy it the beds are being scoured as never before. New and more efficient methods are being introduced, while the fishermen using the old methods on old grounds are taking fewer sponges individually but still find the fishery more or less profitable owing to the higher prices which they are able to obtain.

The outcome of these conditions is inevitably the ultimate depletion of the beds or the economic limitation of their product. The world can produce annually by natural processes alone only a certain more or less definite quantity of sponges. It is obvious from the facts which have been set forth in preceding pages that many beds have reached their limits of productiveness, and that were it not for the higher prices of to-day they could not be fished with profit by the methods which proved lucrative in former years. A bed from which a fraction of the sponges has been removed has not the reproductive and recuperative possibilities which it possessed in its virgin state. Worked as intensely as they are to-day the sponge grounds can not improve; they are almost certain to retrograde, but by wise regulation some of them may be maintained in approximately their present condition of productiveness.

The discovery of great sponge fields in places in which they are not now known or developed, in Australia and the Philippines, for instance, may provide for the future growth of the world's demands, but that will be of no value to

fisheries already established, however desirable it may be from the standpoint of the consumer. Exhausted or partly exhausted fisheries must suffer if brought into competition with those whose productiveness is unimpaired and whose product may be put on the market at a lower price. Those countries which have with forethought provided for the contingencies of the future are those whose fisheries will be best fitted to survive competition, or, should that not come, be in a position to reap the greatest profit from the increased demand for their product.

To secure to the people of Florida the conservation of the natural beds, for the maintenance of the fisheries already established, to regulate those which may be introduced in the future, and to provide for an increase in the sponge supply to meet the growing demands of civilization, changes in the federal and state statutes are suggested to meet the following requirements in addition or amendment to those already provided for:

1. The minimum size of sponges allowed to be taken, landed, or sold should be increased from 4 inches to 5 inches in their maximum diameter. This would prevent the present wasteful destruction of sponges commercially almost worthless, would conserve the beds, and after one year would increase the income of the fishermen without materially decreasing it in the meantime.

2. In addition to the restrictions now in force, the use of the scaphander should be prohibited in water deeper than 20 fathoms. This is intended primarily as a hygienic measure, to protect the divers from the evil results attending work in deep water, but it will also indirectly protect the workable beds by maintaining outside of them a possible reserve of spawning sponges to supply them with young.

3. Gangavas, dredges, trawls, and similar instruments for scraping the bottom should be prohibited in depths of less than 30 fathoms. This regulation, while not required by any present development of the fishery, will prevent the sudden unregulated development of a method which would undoubtedly be destructive to the inshore grounds.

4. State and federal laws should be enacted for the encouragement of sponge culture in both territorial and extraterritorial waters, securing to private individuals or corporations the sole use, under proper restrictions, of suitable areas of the bottom for the purpose of raising sponges by artificial means. In case of further depletion of the natural beds, or with the growth of demand and the failure to discover new and more productive grounds, sponge culture offers the only possible means of prevention of a practical sponge famine. With the development of sponge fields in other parts of the world which would be serious competitors with the depleted beds of Florida, the practice of an economic system of sponge culture is the only means which would prevent the extermination of the lucrative sponge business of the state.

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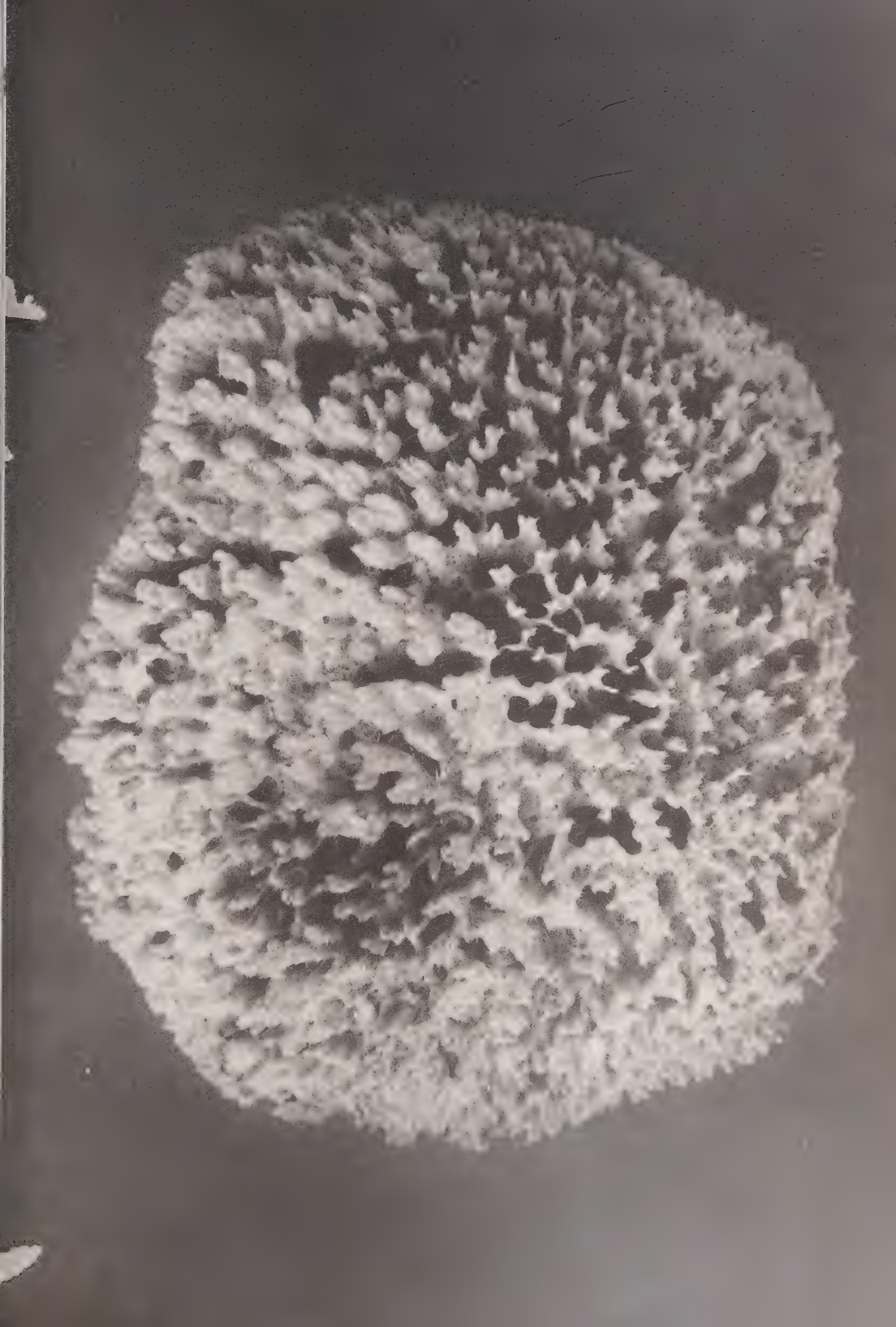

Plate XXXI

Rock Island sheepswool sponge, top view. Three-fourths natural size.

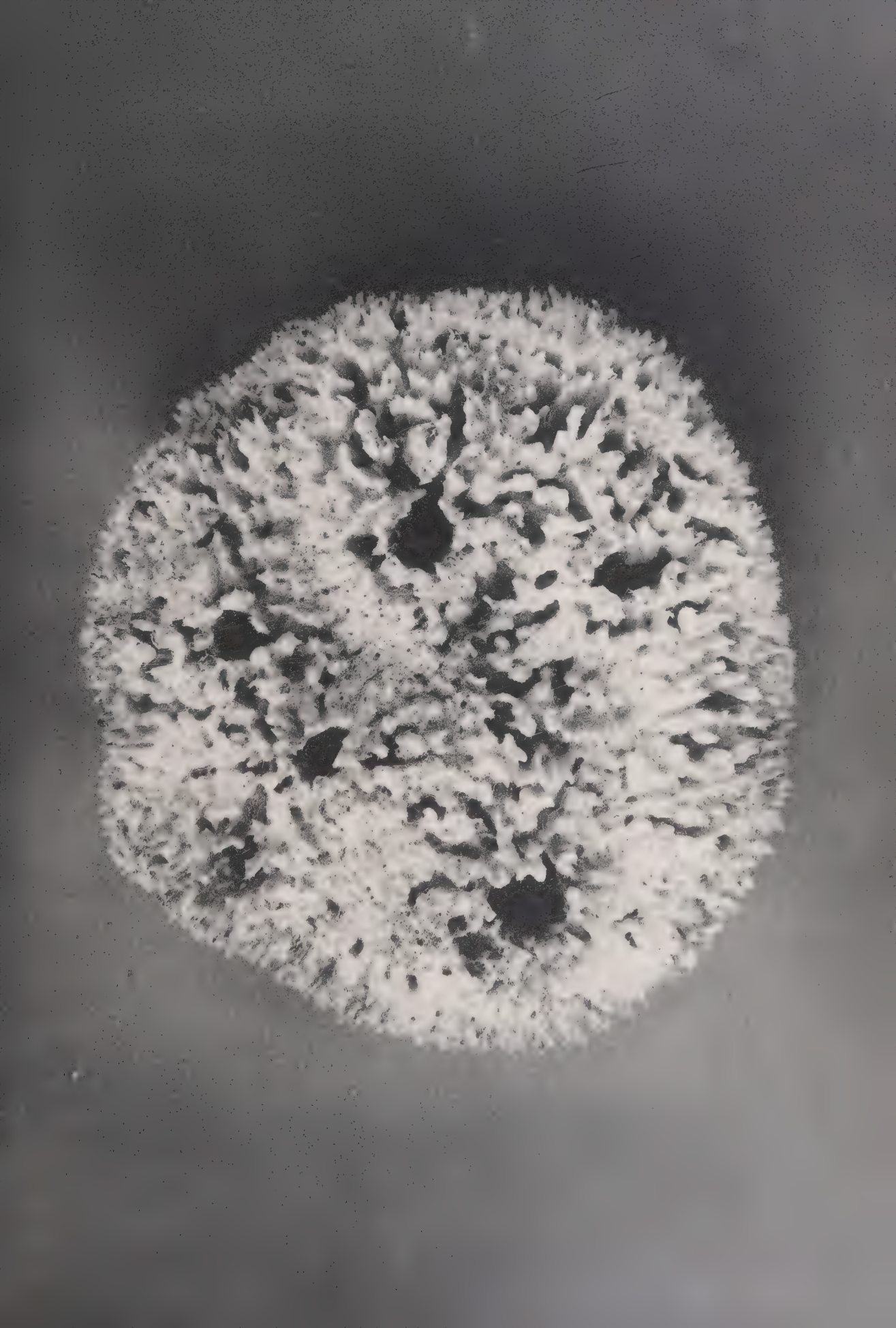

Plate XXXII

Florida Key sheepswool sponge. Natural size.

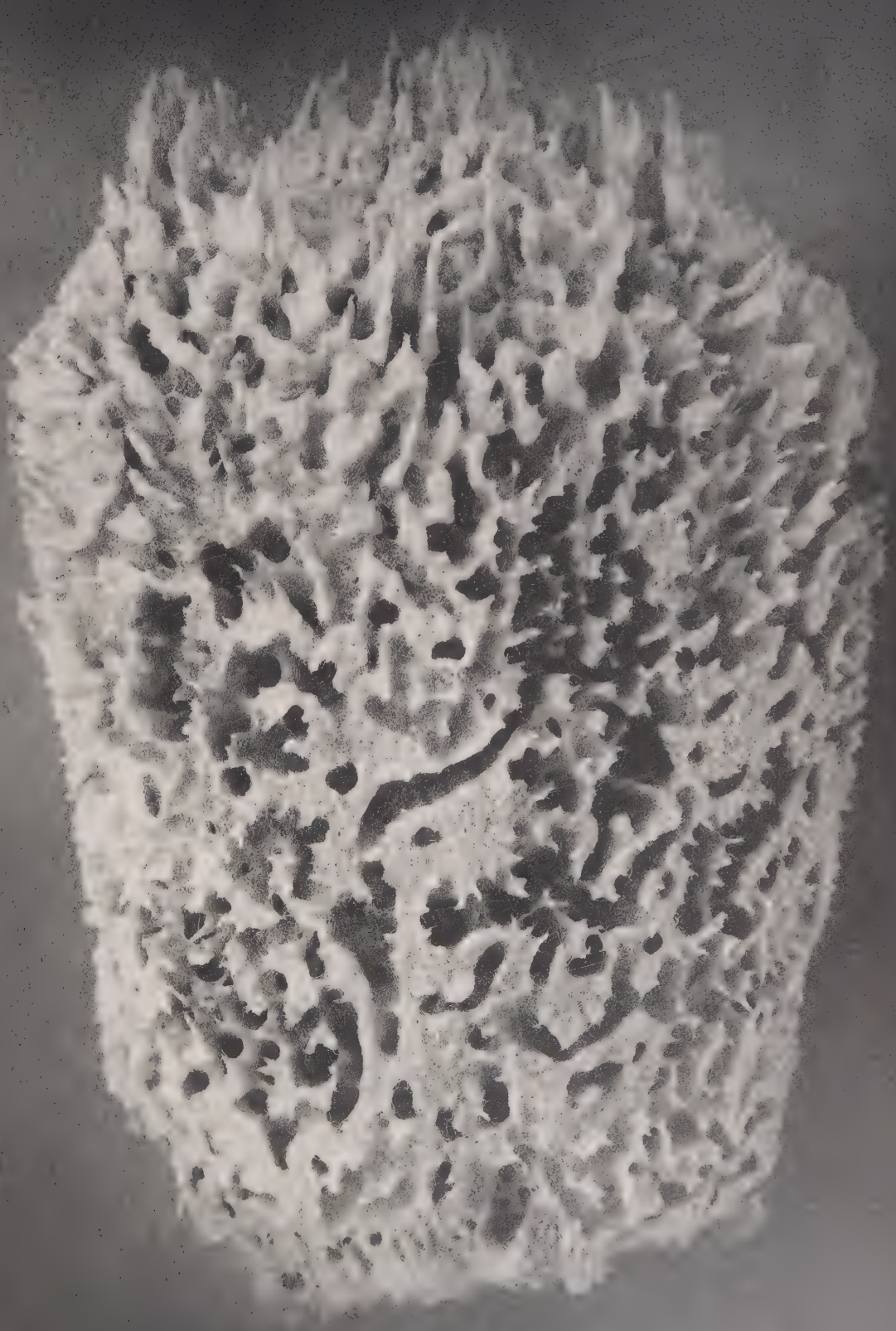

Plate XXXIII

Matecumbe Key sheepswool sponge. Natural size.

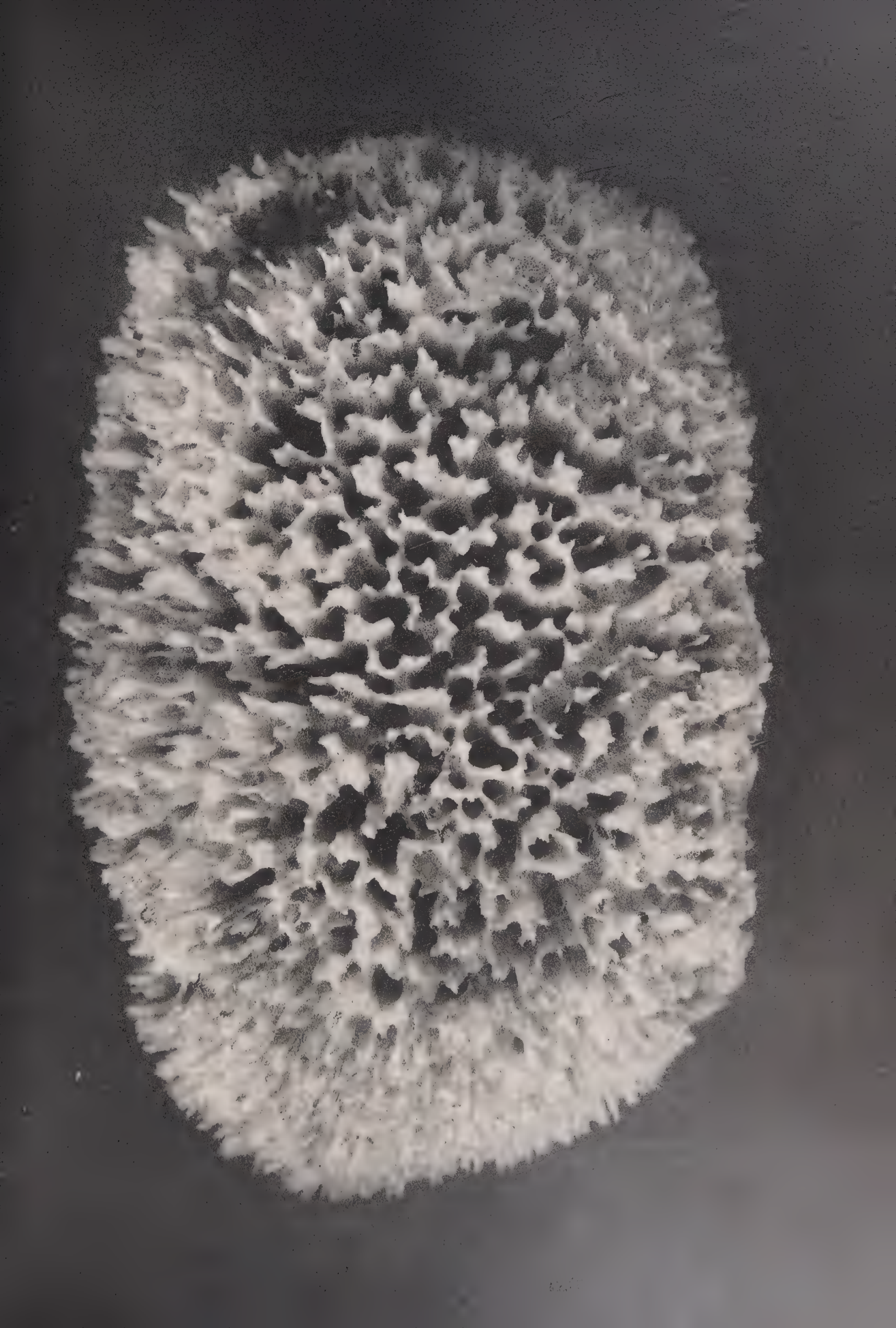

Plate XXXIV

Nassau sheepswool sponge, Bahama Islands. Natural size.

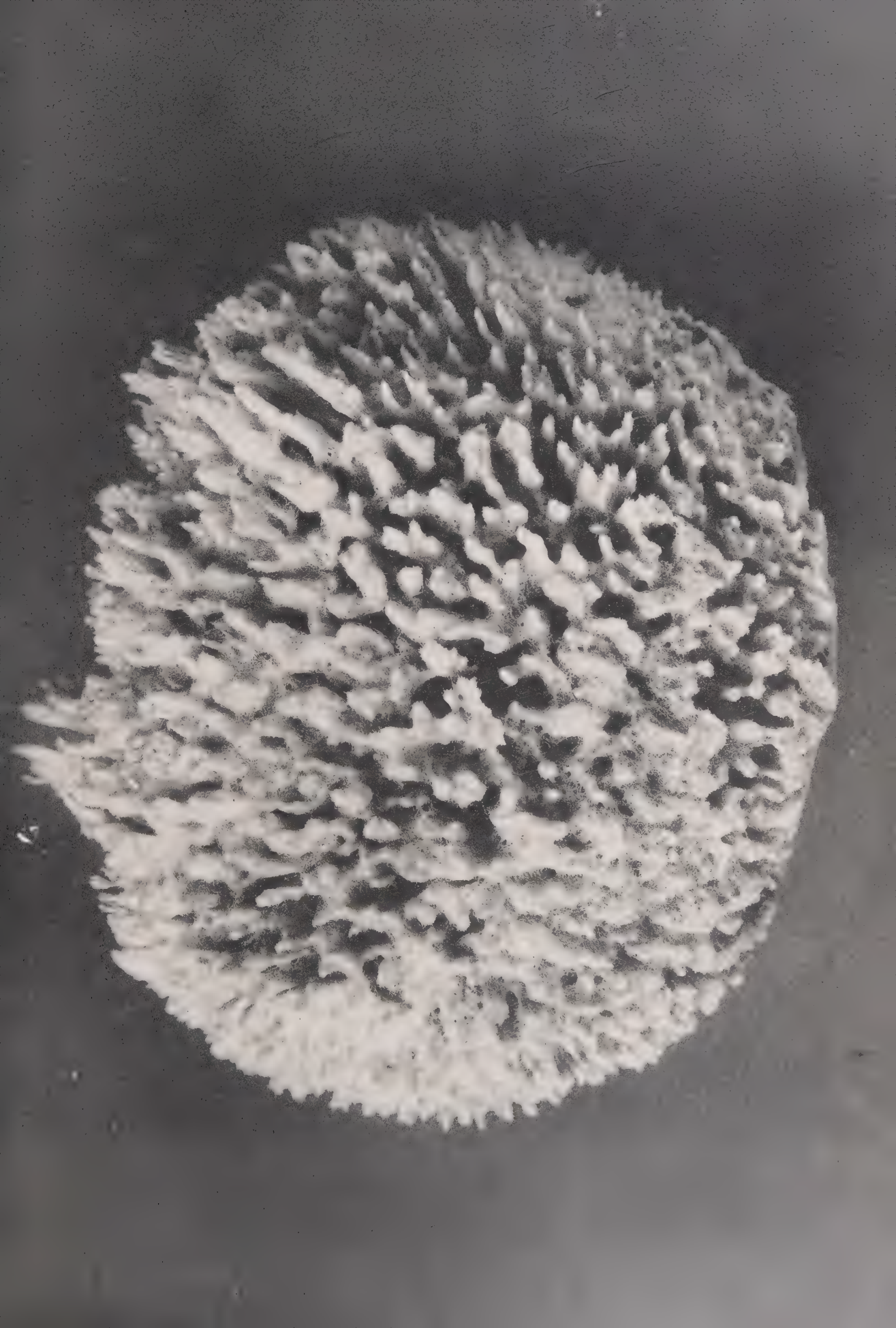

Plate XXXV

Abaco sheepswool sponge, Bahama Islands. Natural size.

Plate XXXV

Abaco sheepswool sponge, Eudiana lukensis. Natural size.

Plate XXXVI

Cuba sheepswool sponge. Natural size.

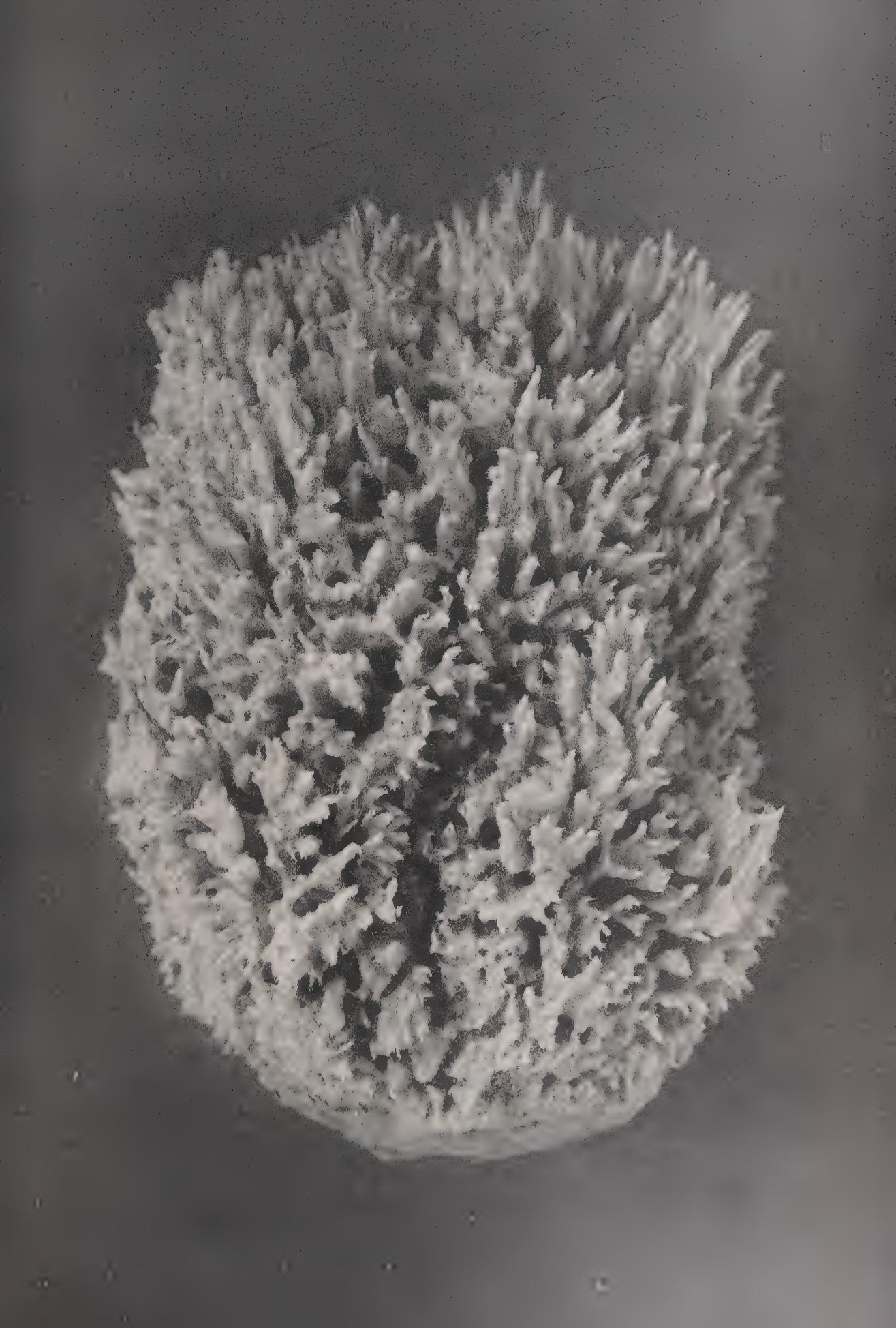

Plate XXXVII

Florida Key yellow sponge. Natural size.

Plate XXXVII

Florida Key yellow opossum. Natural size.

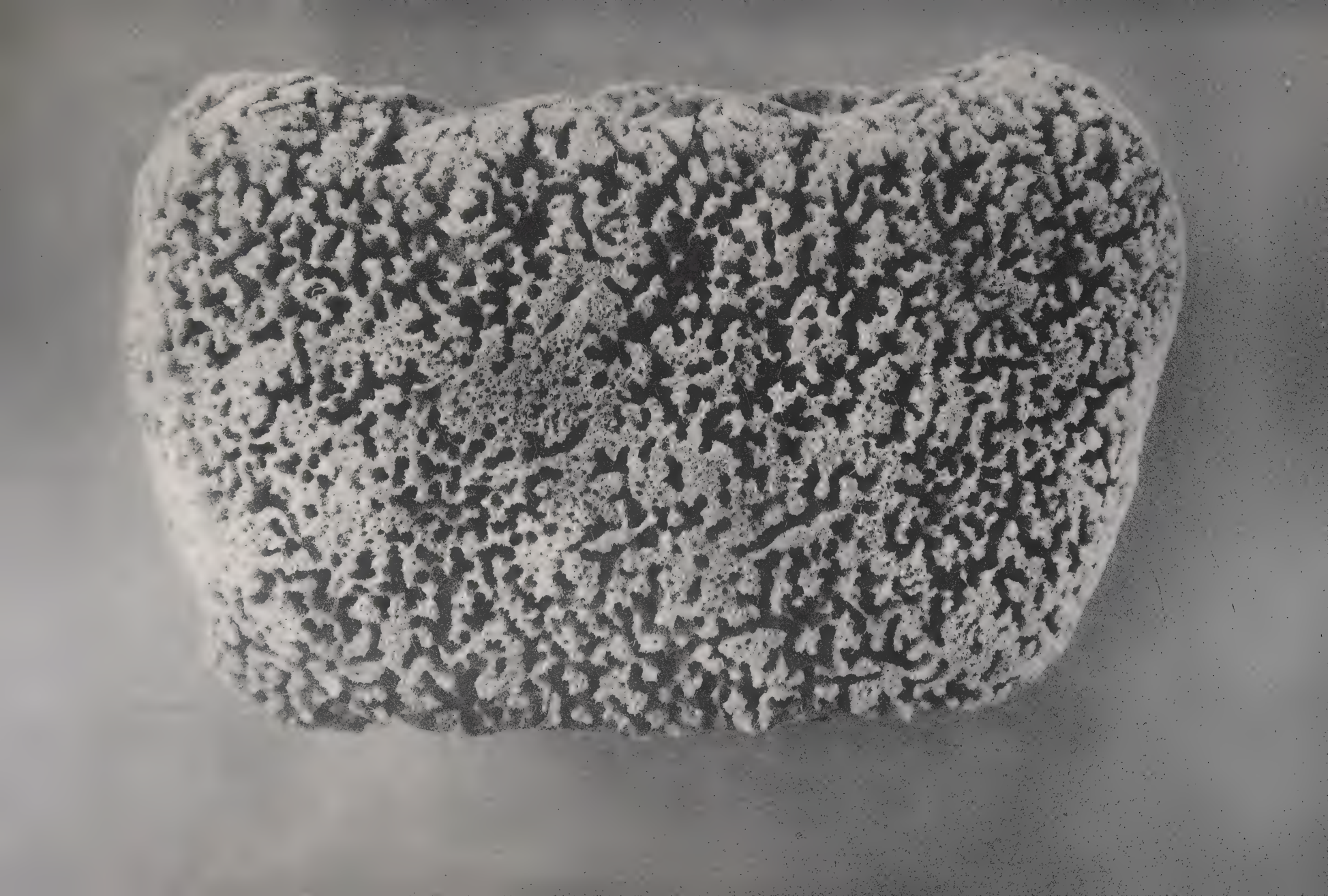

Plate XXXVIII

Florida Key yellow sponge, top view. Natural size.

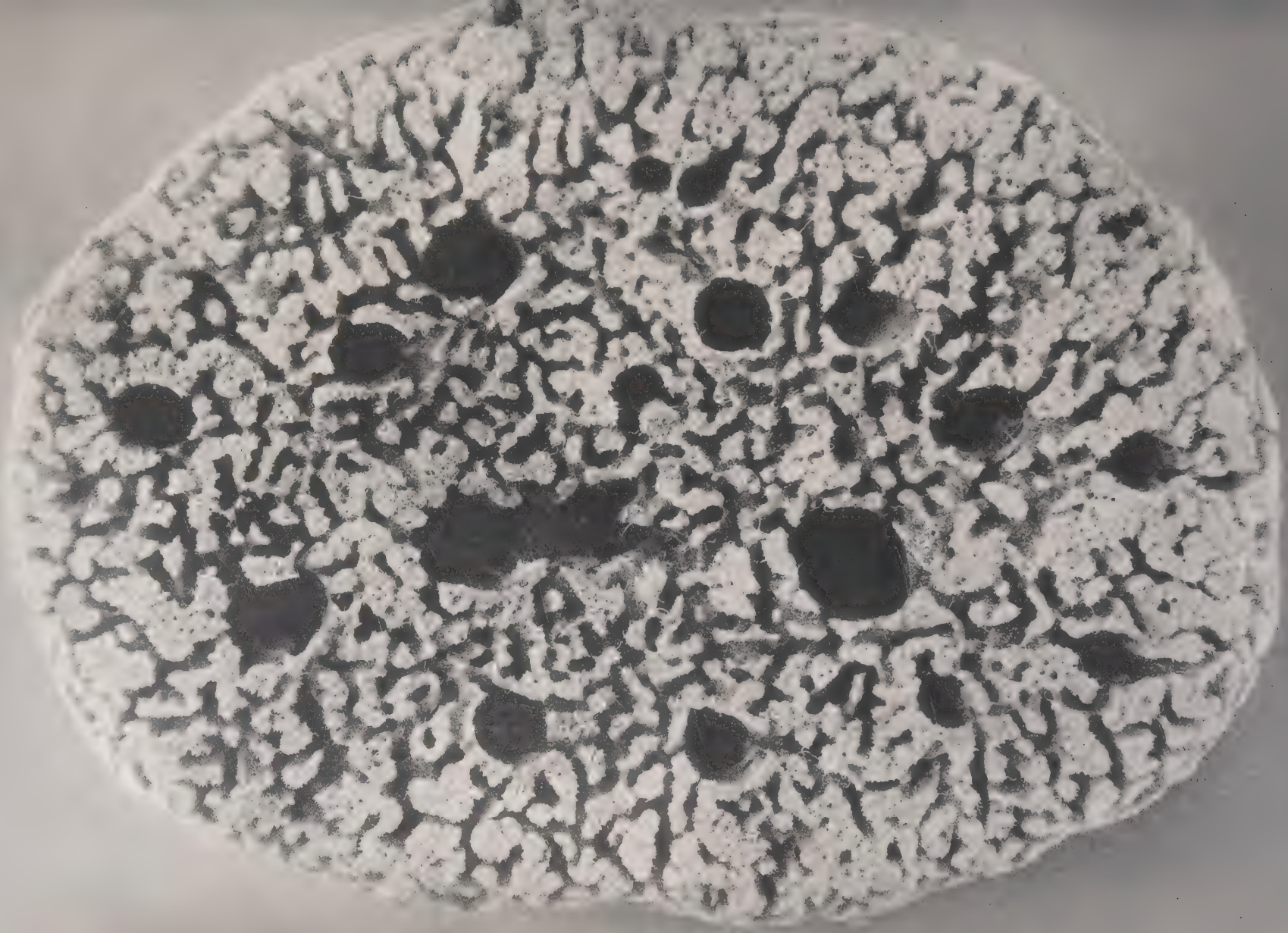

Plate XXXIX

Florida Key yellow sponge. Natural size.

Plate XL

Anclote yellow sponge. Natural size.

Plate VI.

Asclepias yellow sponge. Natural size.

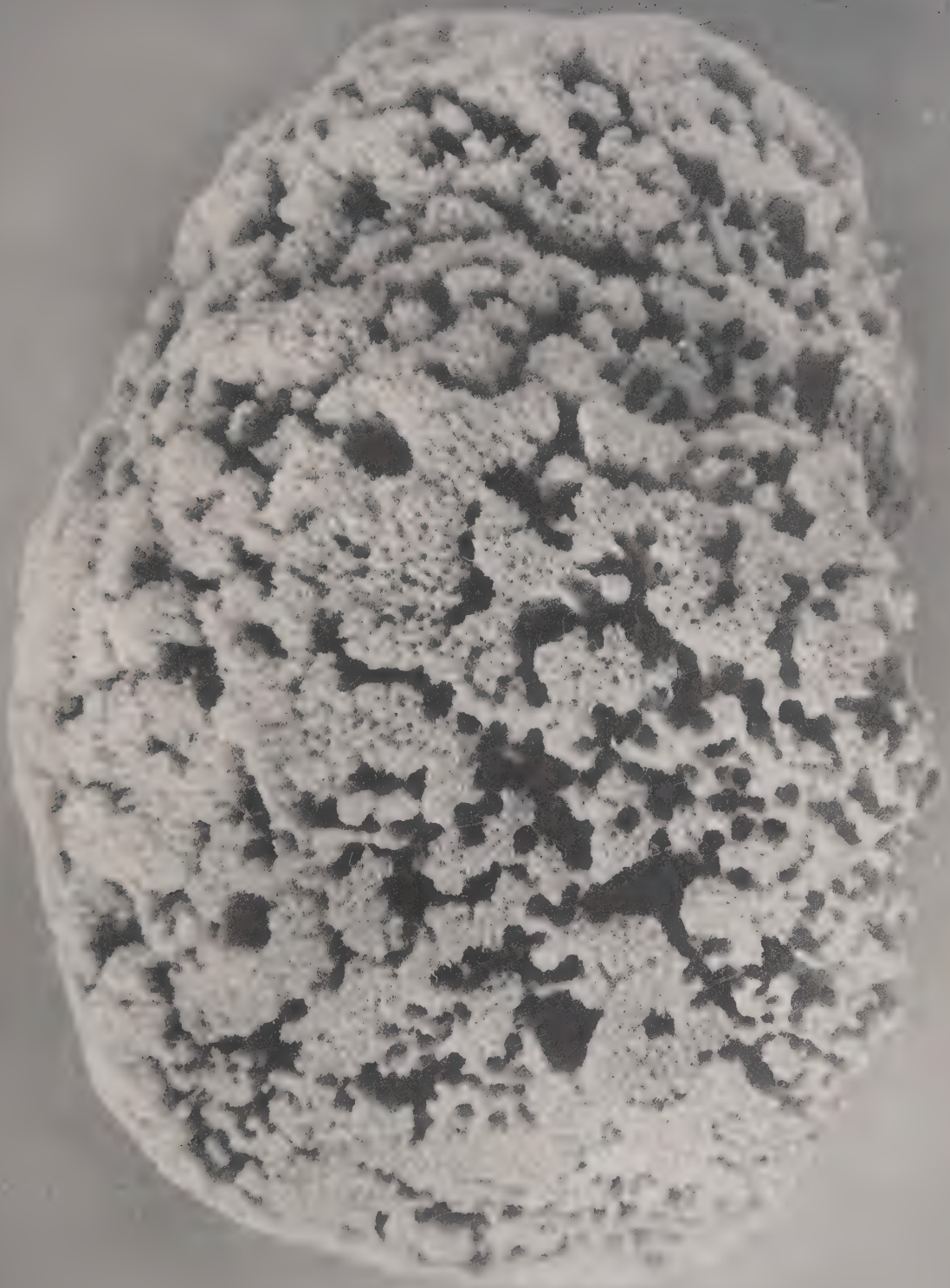

Plate XLI

Anclote yellow sponge. Natural size.

Plate XLII

Bahama yellow sponge. Natural size.

Plate XLIII

Bahama yellow sponge. Natural size.

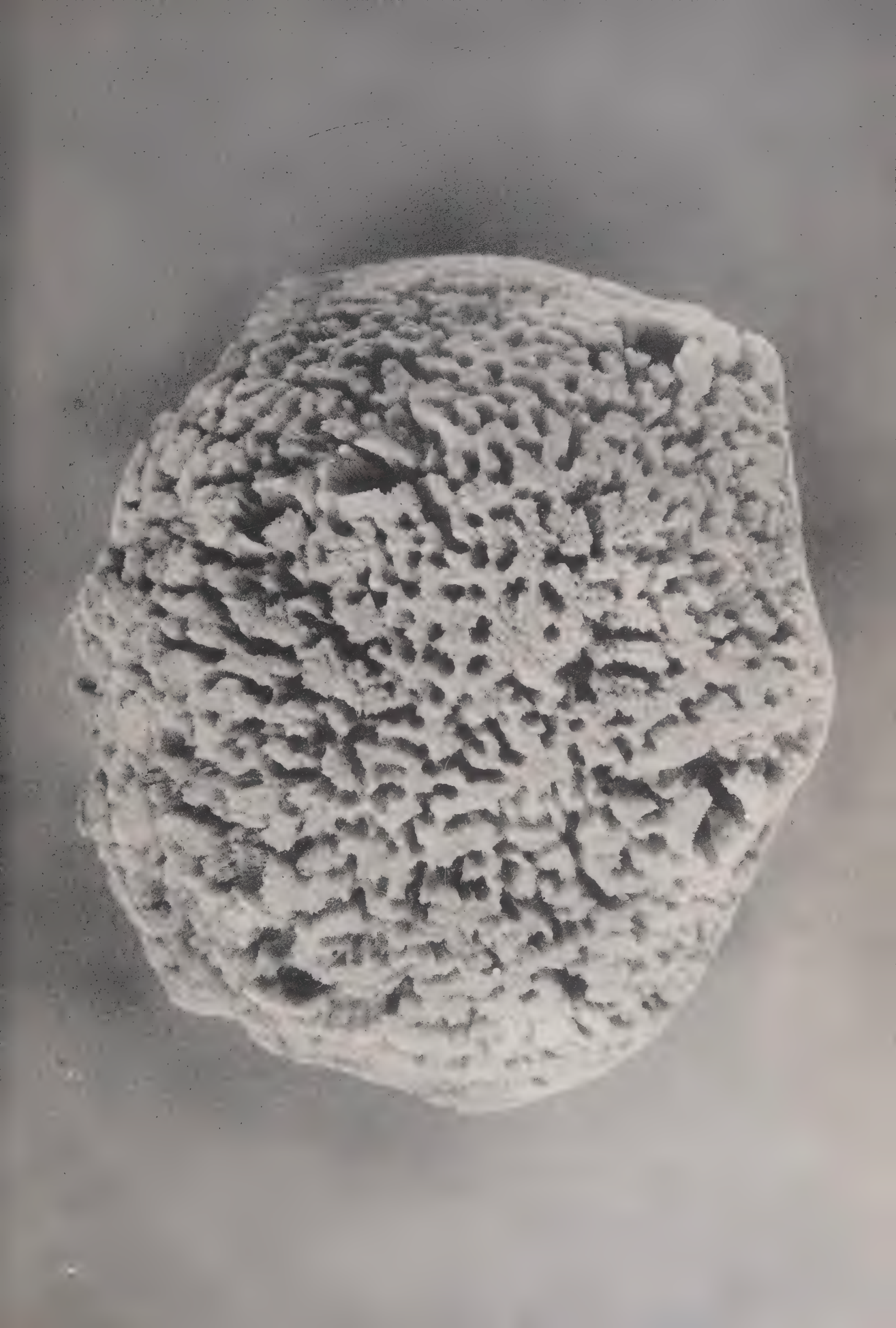

Plate XLIV

Cuba yellow sponge. Natural size.

Plate XLIV

Cliona vallon sponge. Natural size.

Plate XLV

Florida velvet sponge, top view. Natural size.

Plate XLV

Florida velvet sponge, top view. Natural size.

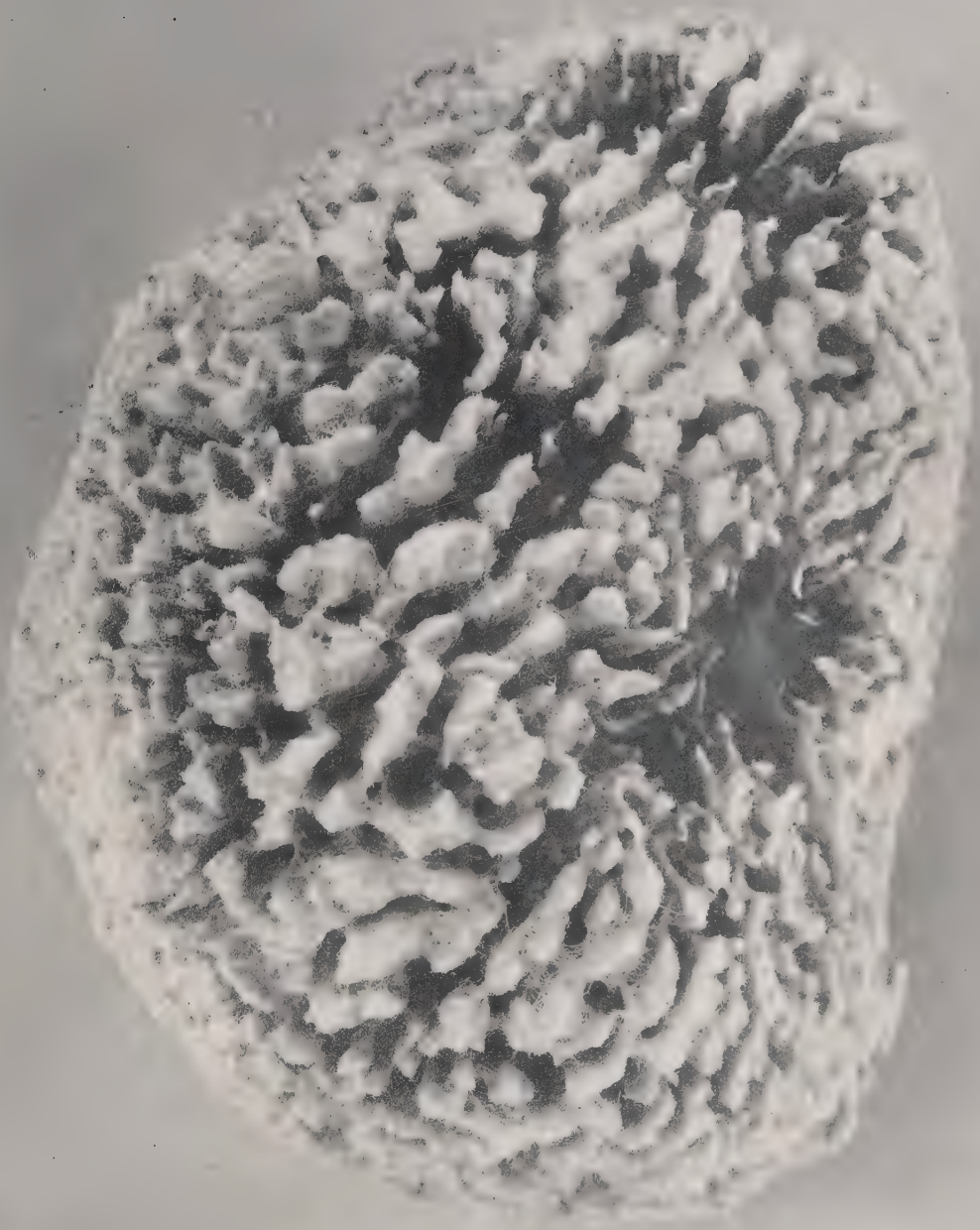

Plate XLVI

Bahama velvet sponge. Natural size.

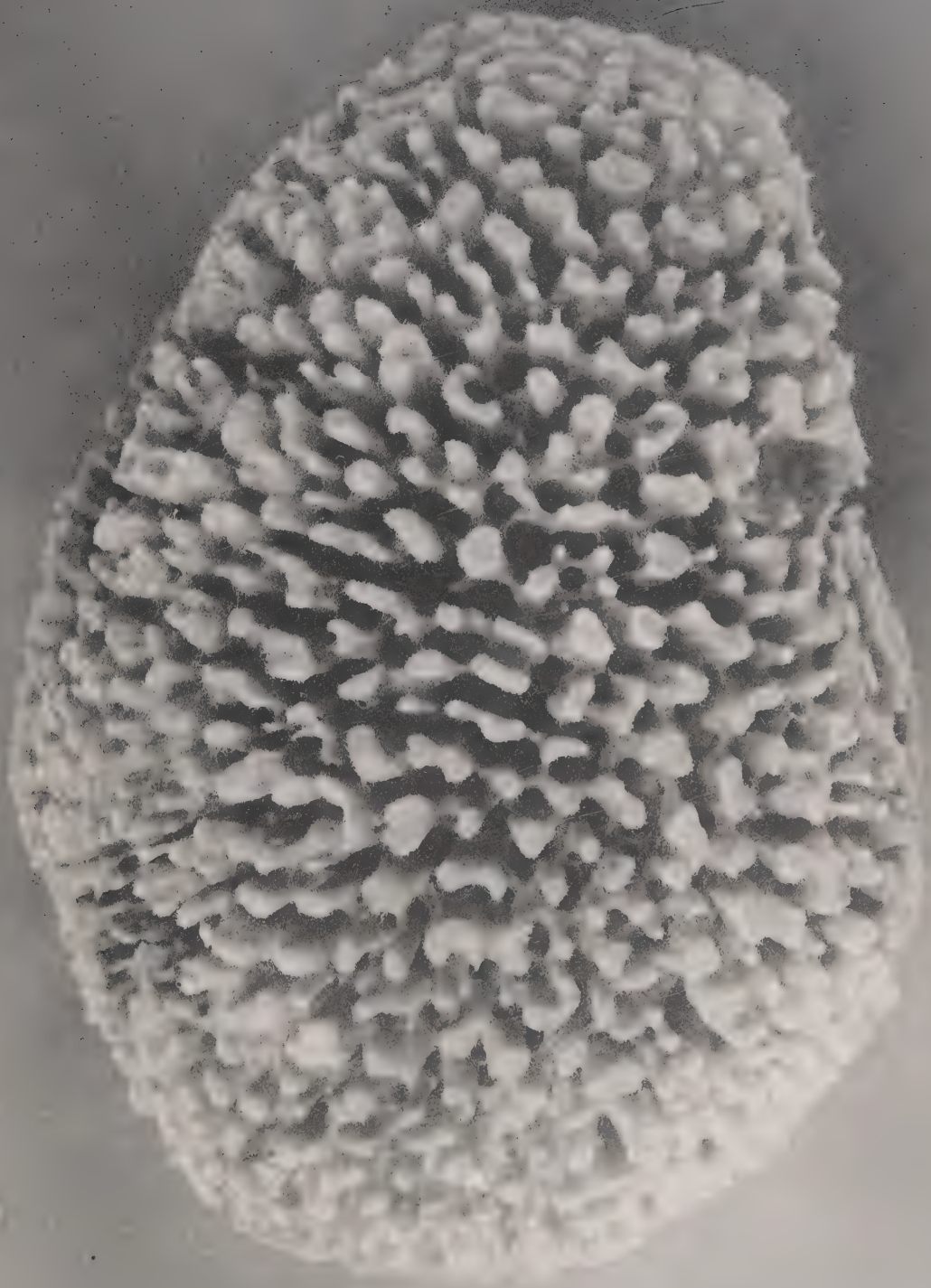

Plate XLVII

Cuba velvet sponge. Natural size.

Plate XLVIII

Anclote grass sponge. Natural size.

Plate XLVIII

Anclote grass sponge. Natural size.

Plate XLIX

Florida Key grass sponge. Natural size.

Plate L

Florida Key grass sponge. Natural size.

Plate LI

Florida Key grass sponge, top view. Natural size.

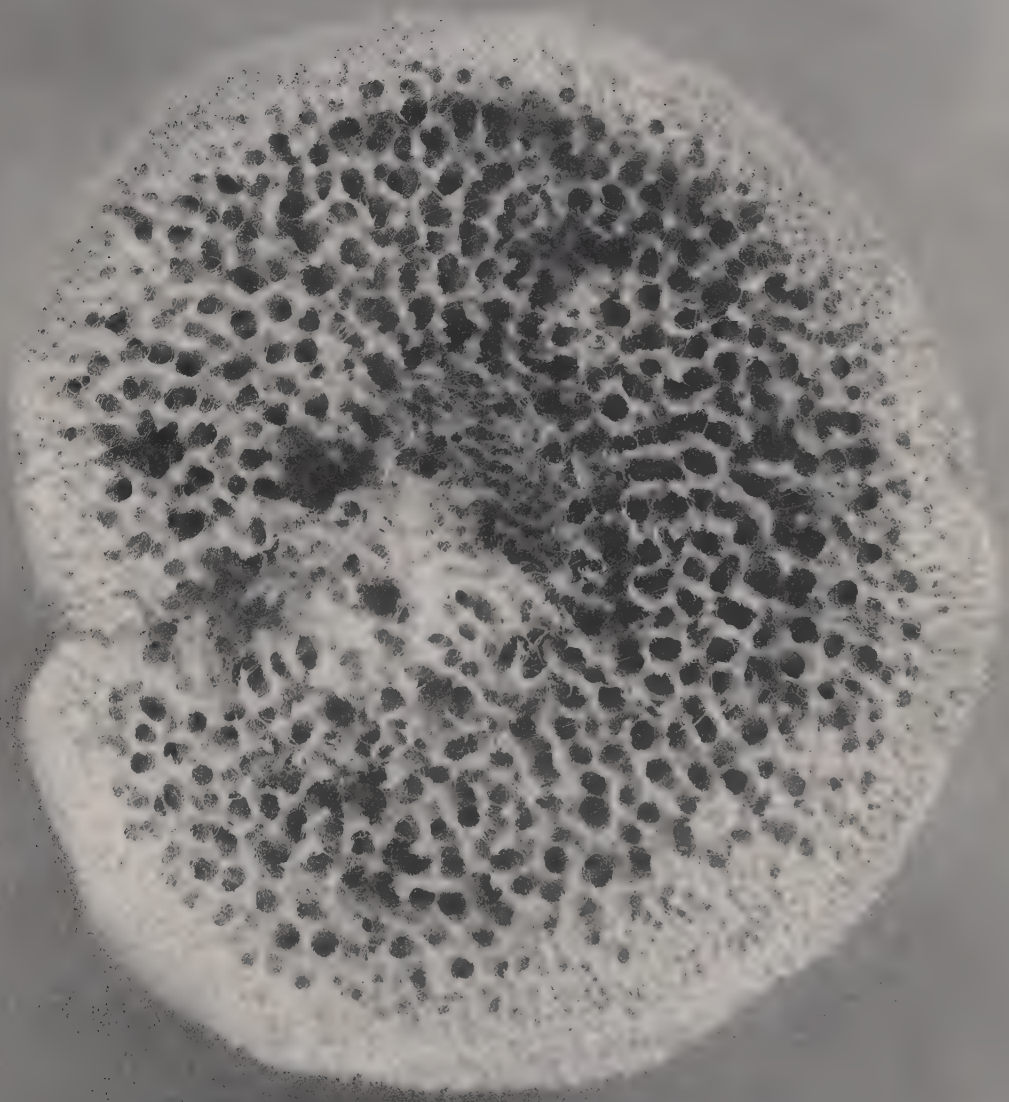

Plate LII

Bahama grass sponges. Natural size.

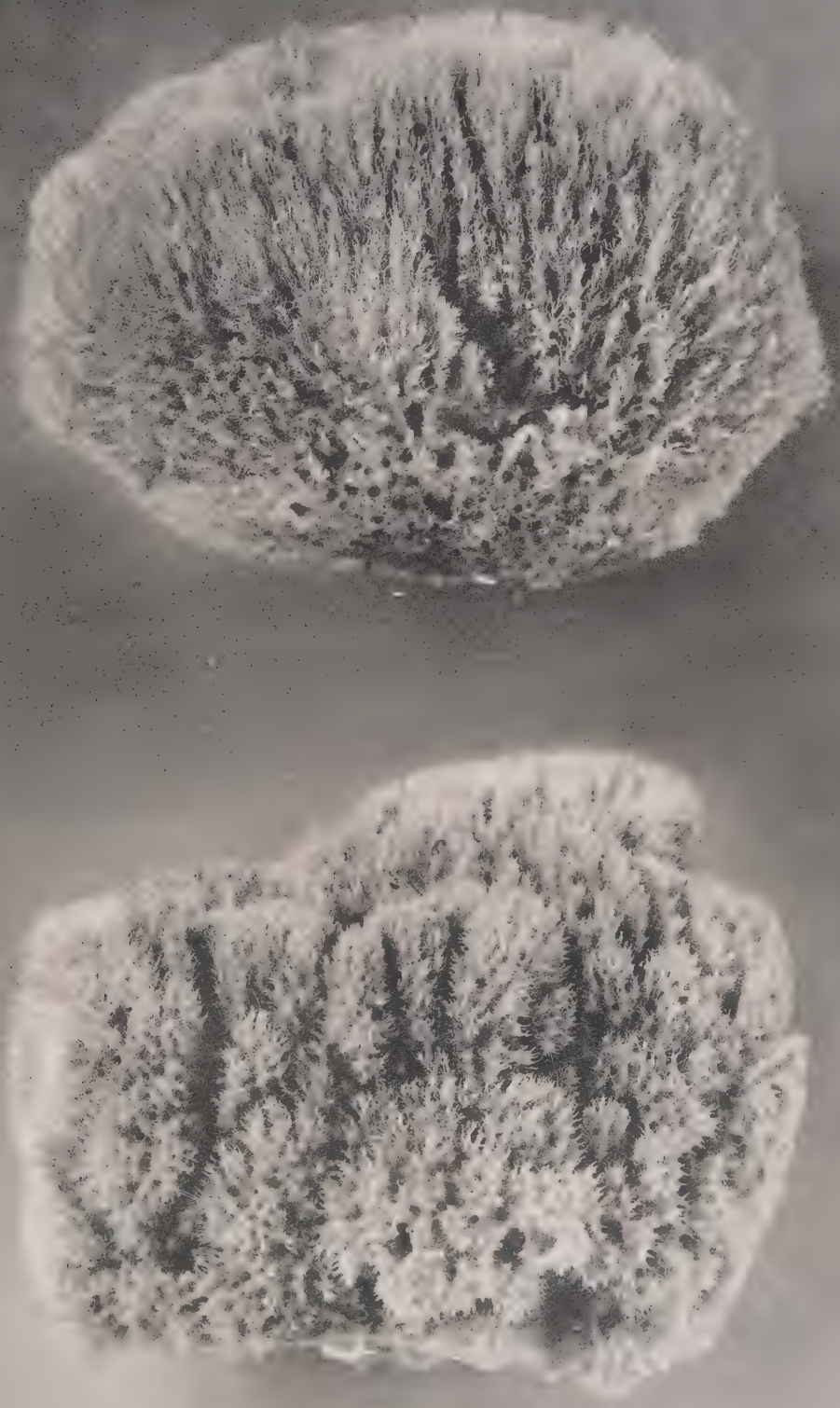

Plate LIII

Cuba grass sponges. Natural size.

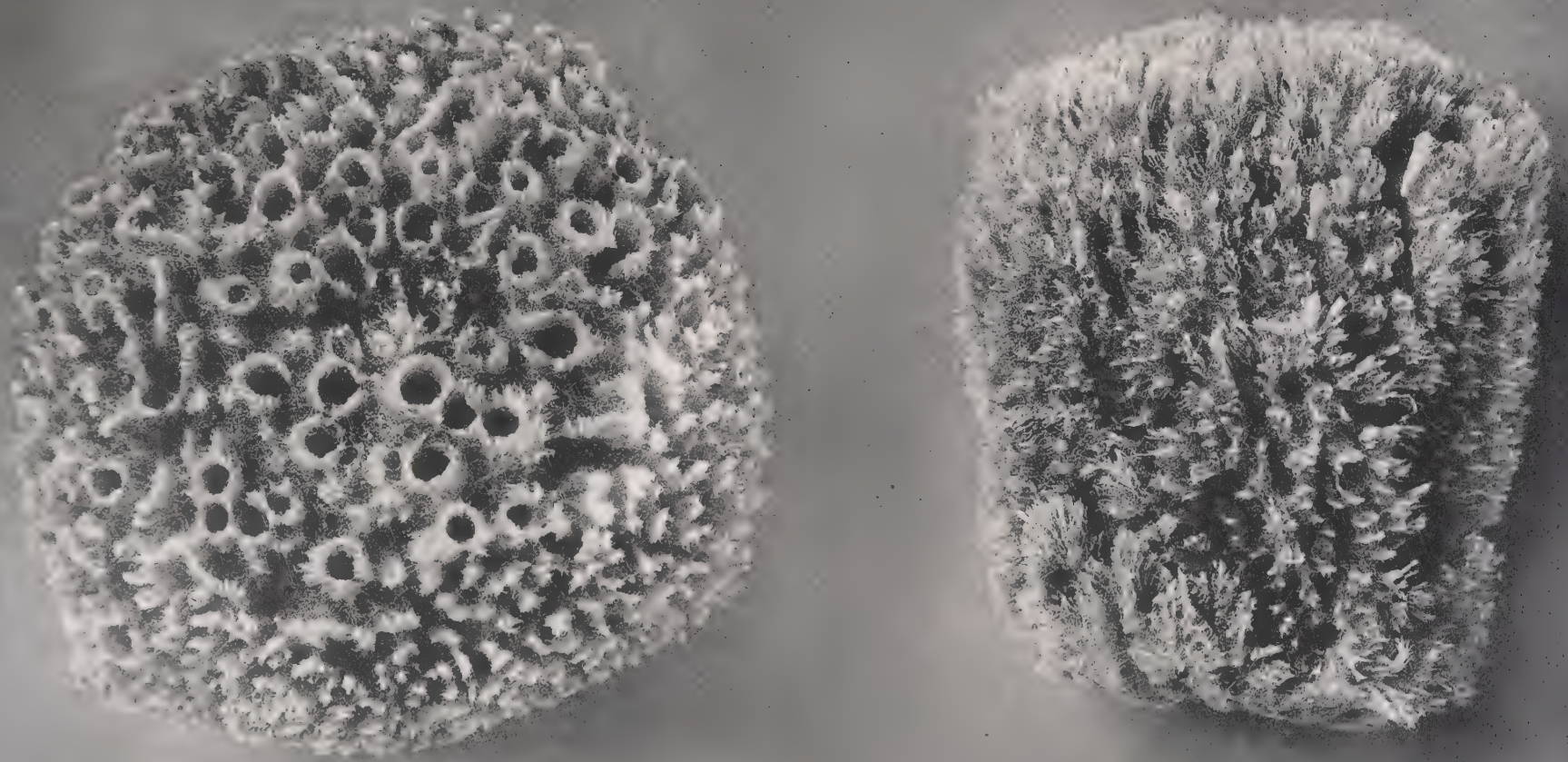

Plate LIV

Florida glove sponge. Natural size.

Plate LIV

Florida glove sponge. Natural size.

Plate LV

Cuba reef sponge. Natural size.

Plate LVI

Fig. 1.—Bahama reef sponge, side view. Natural size.

Fig. 2.—Bahama reef sponge, top view. Natural size.

Plate LVI

Fig. 1.—Bahama reef sponge, side view. Natural size.

Fig. 2.—Bahama reef sponge, top view. Natural size.

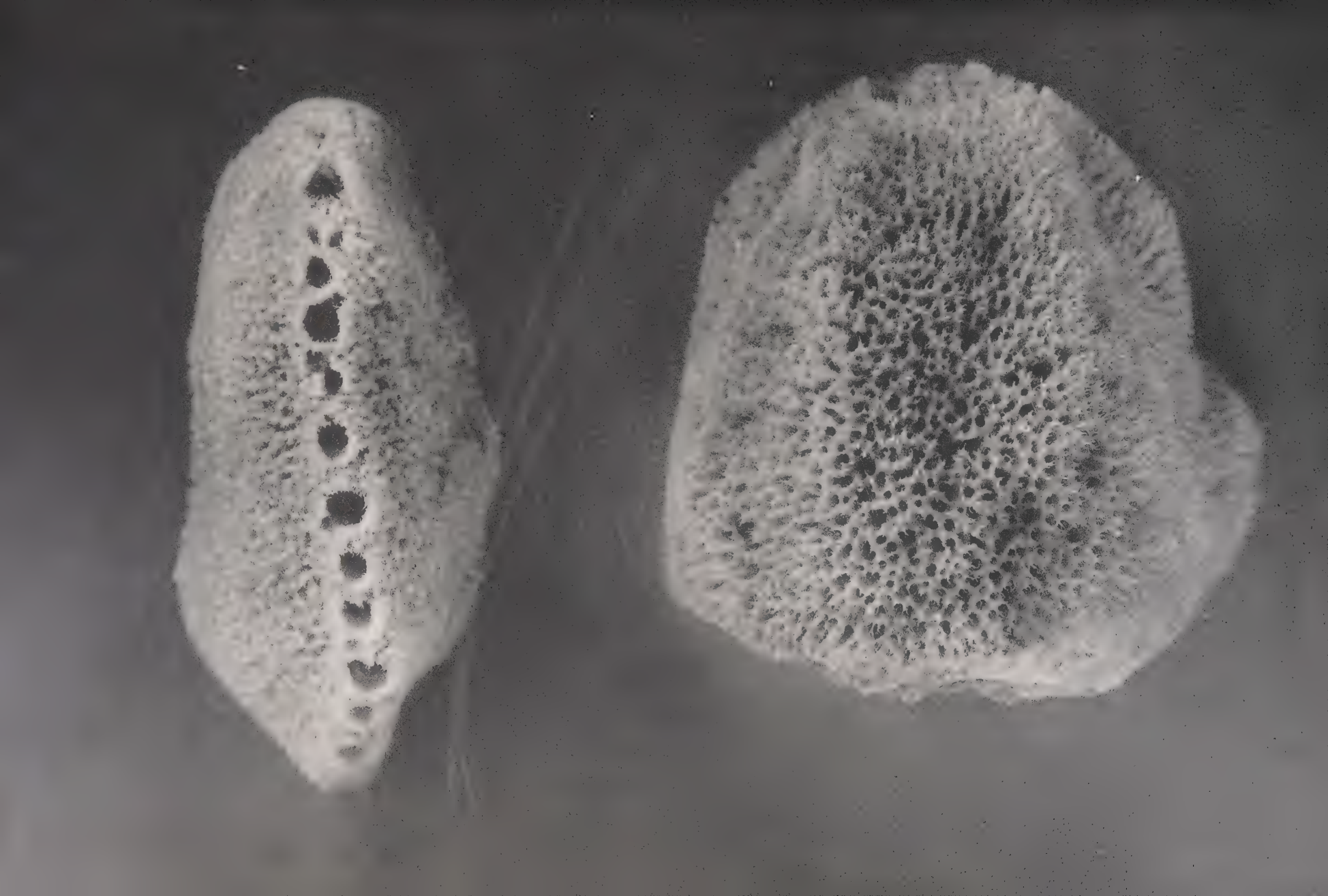

Plate LVII

Cuba hardhead sponges. Natural size.

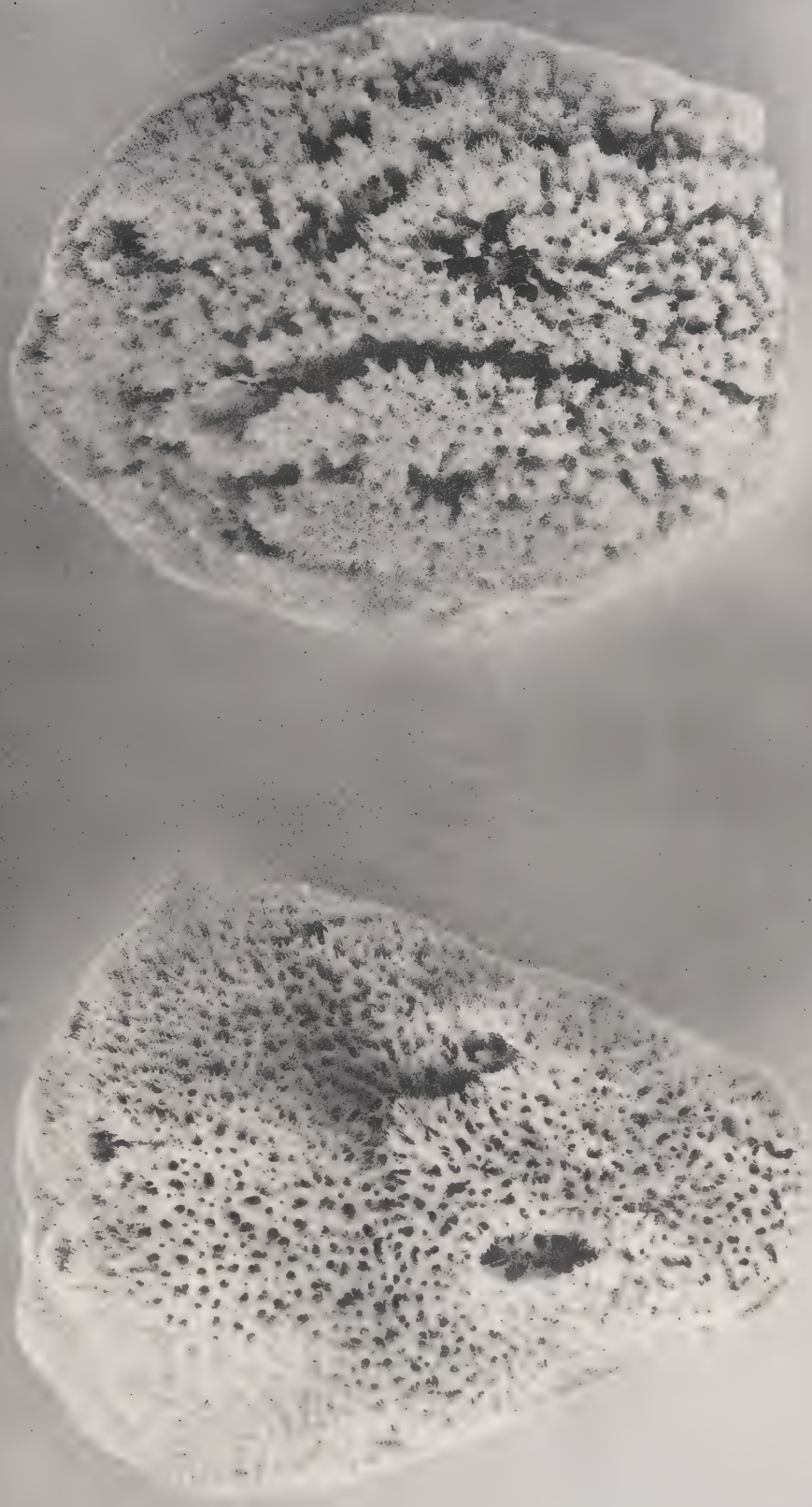

Plate LVIII

Florida wire sponge. Natural size.

Plate LVIII

Florida wire sponge. Natural size.

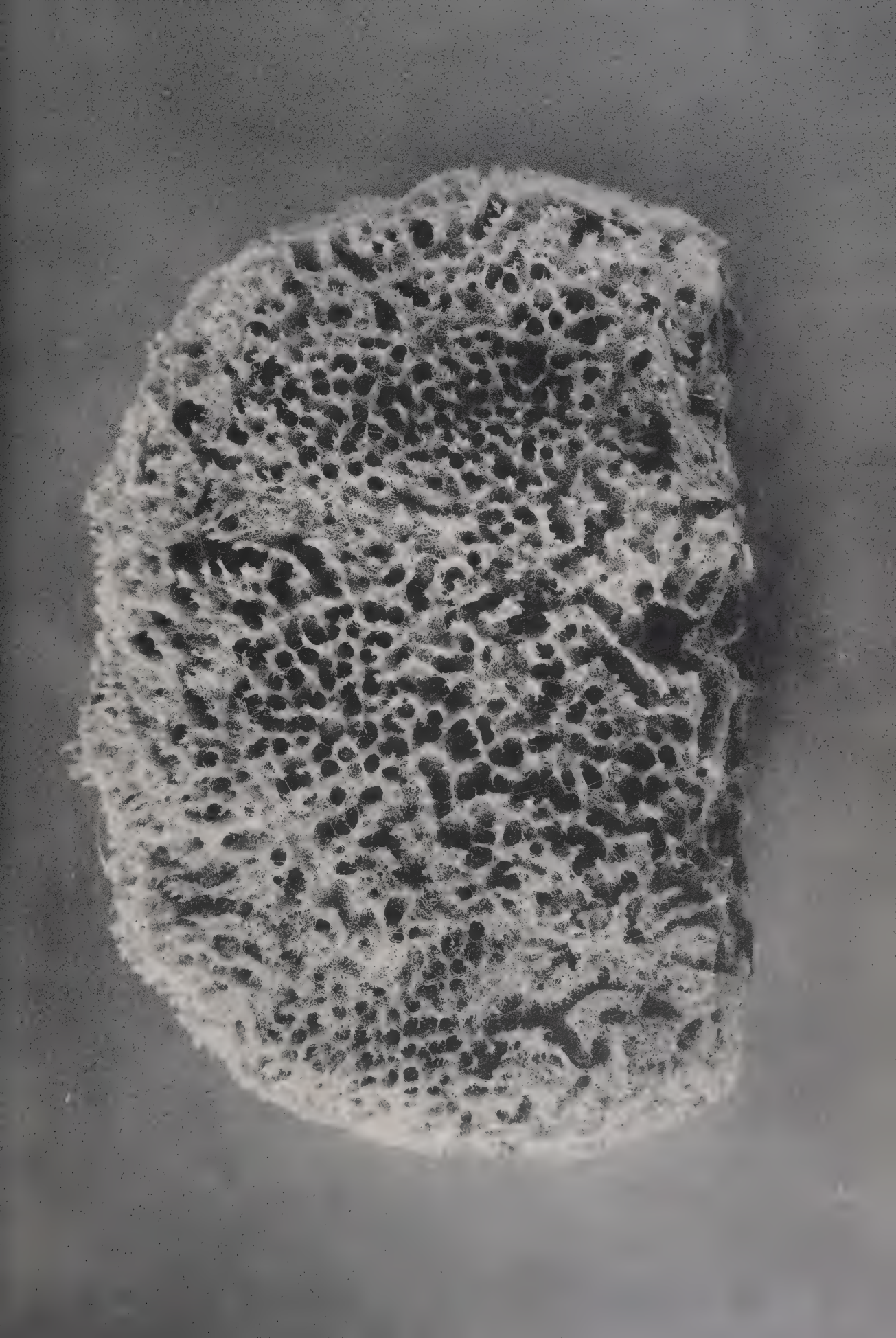

Plate LIX

Florida wire sponge, top view. Natural size.

Plate LIX

Florida wire sponge, top view. Natural size.

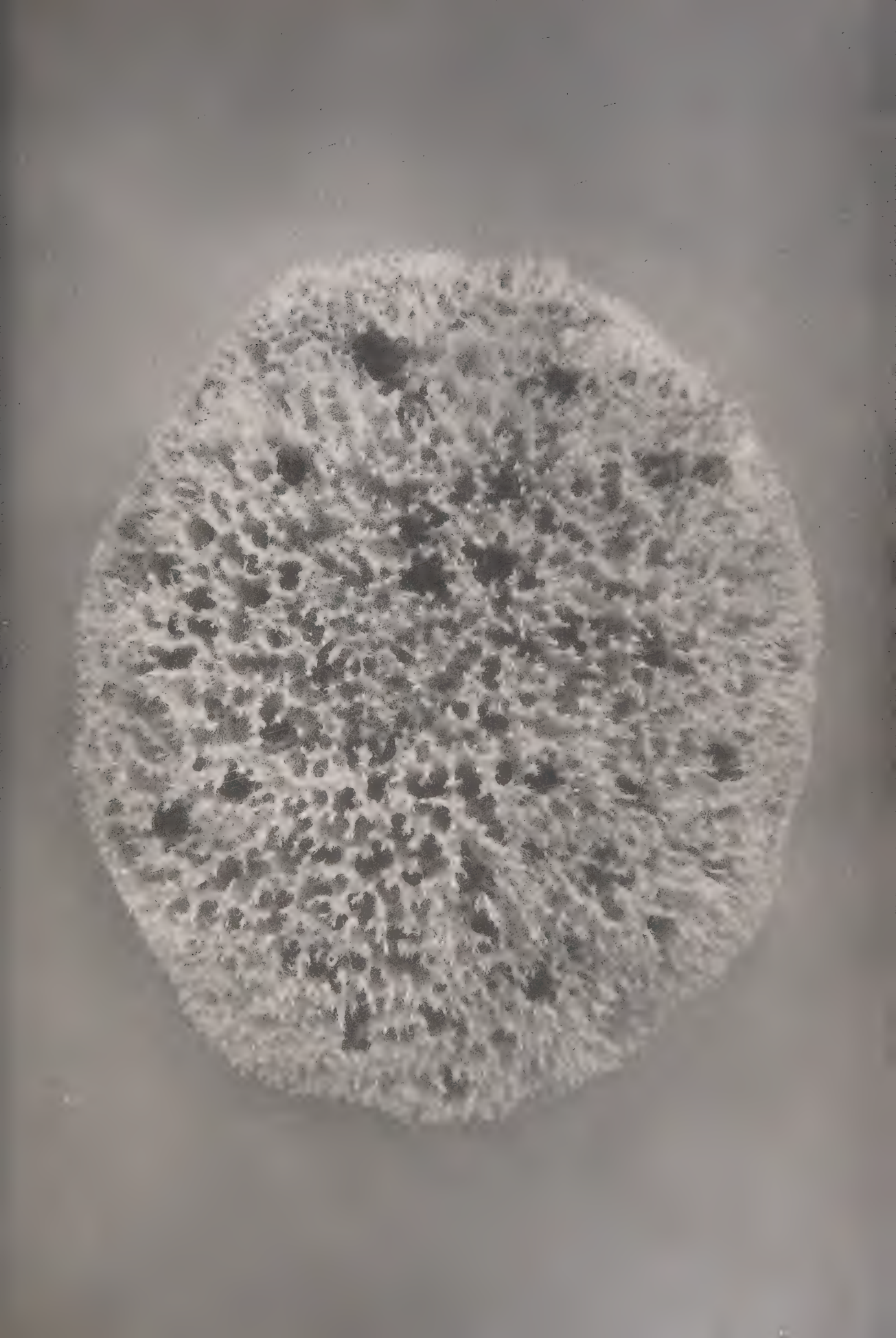

Plate LX

Turkey cup sponges, Mediterranean Sea. Natural size.

Plate LXI

Fig. 1.—Turkey solid sponge, Mediterranean Sea. Natural size.

Fig. 2.—Toilet sponge, Mediterranean Sea. Natural size.

Plate LXI

Fig. 1.—Turkey solid sponge, Mediterranean Sea. Natural size.

Fig. 2.—Turkey sponge, Mediterranean Sea. Natural size.

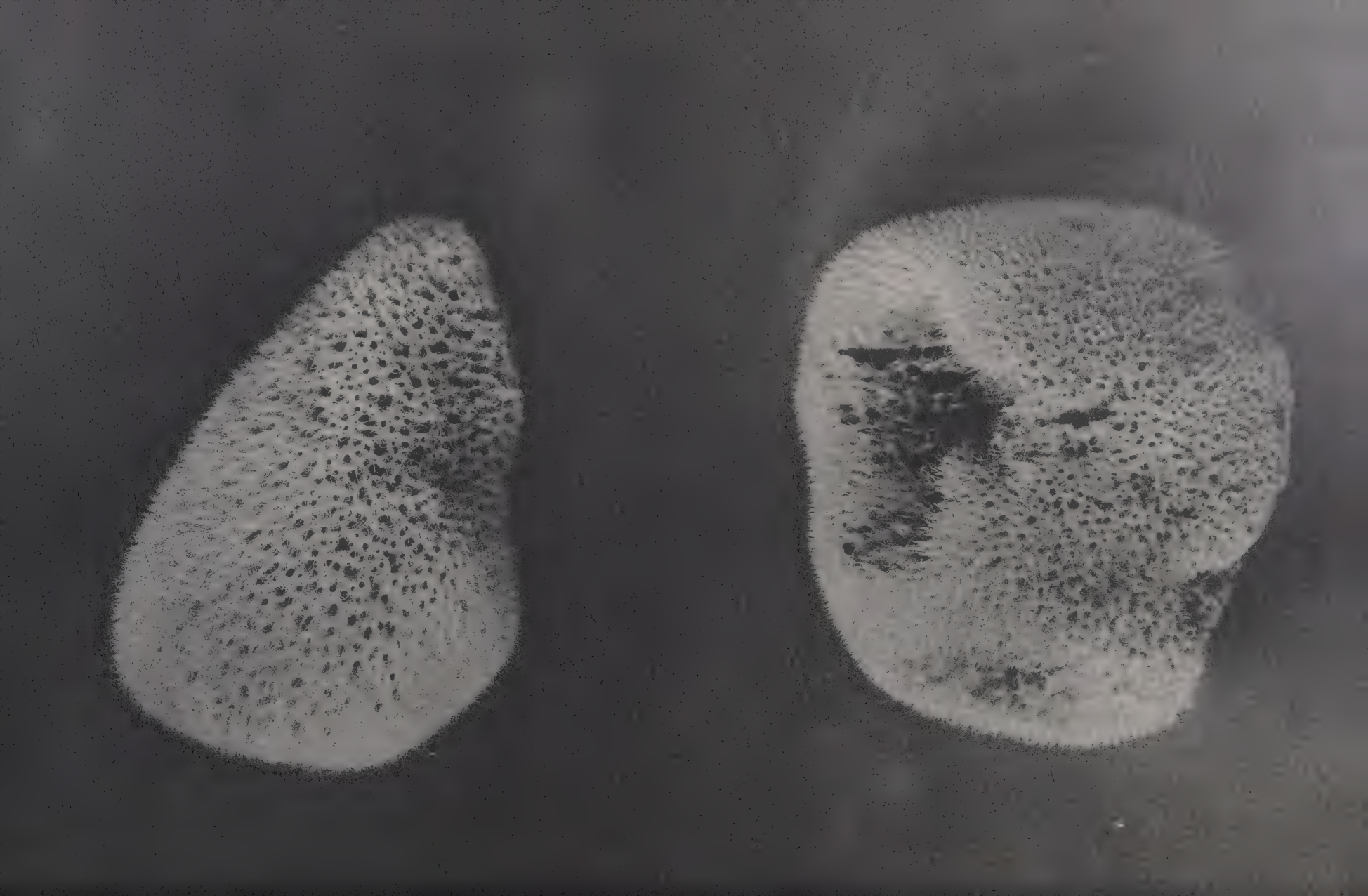

Plate LXII

Toilet sponge, Mediterranean Sea. Natural size.

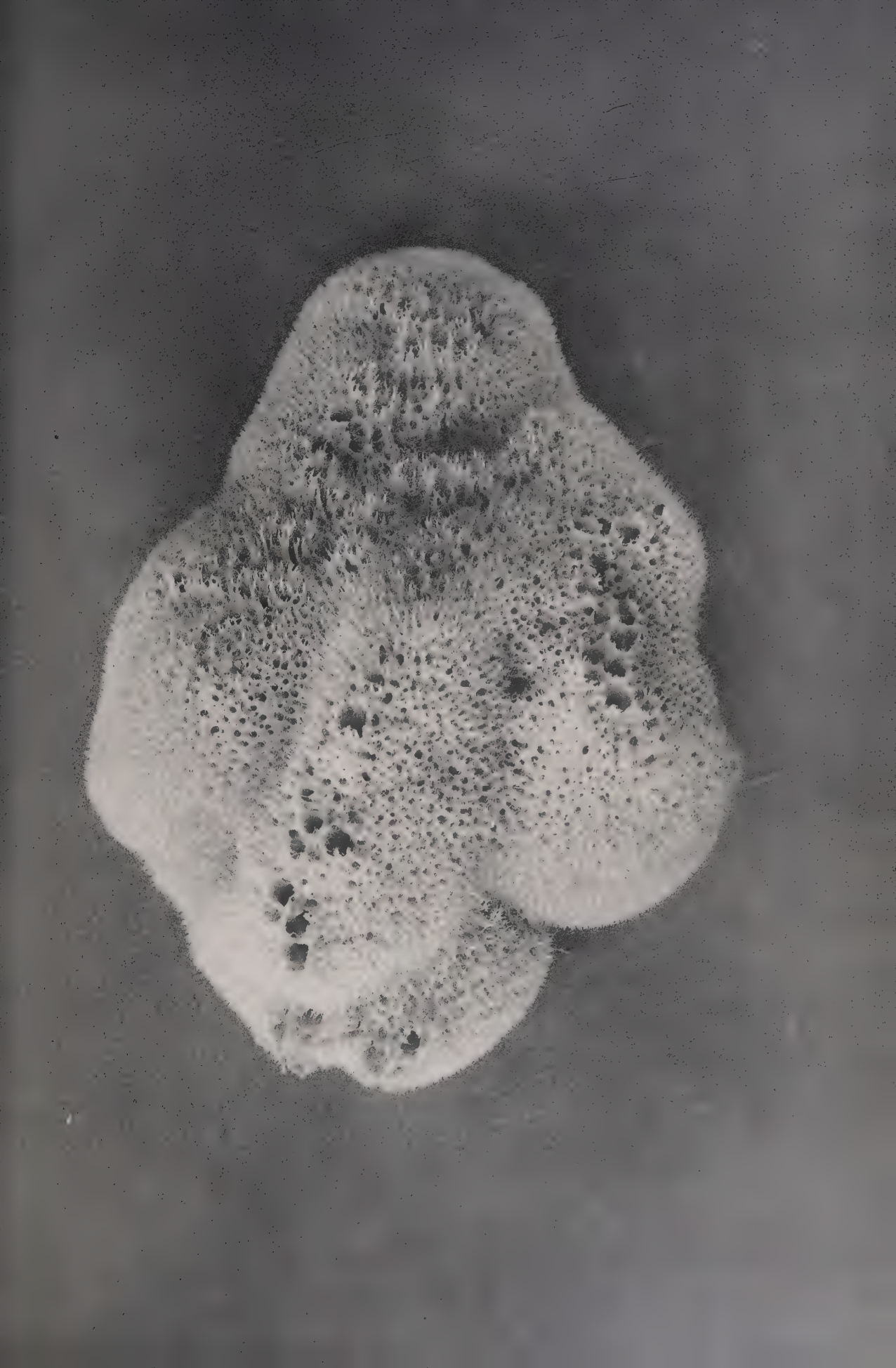

Plate LXIII

Fig. 1.—Philippine toilet sponge, Sitanki, P. I. Side view, natural size.

Fig. 2.—Philippine toilet sponge, Sitanki, P. I. Top view, natural size.

Plate LXIII

Fig. 1. Philippine toilet sponge, Sitankli, P. I. Side view, natural size.

Fig. 2.—Philippine toilet sponge, Sitankli, P. I. Top view, natural size.

Plate LXIV

Fig. 1.—Zimocca sponge, Mediterranean Sea. Side view, natural size.

Fig. 2.—Zimocca sponge, Mediterranean Sea. Top view, natural size.

Plate LXIV

Fig. 1.—Zimocca sponge, Mediterranean Sea. Side view, natural size.

Fig. 2.—Zimocca sponge, Mediterranean Sea. Top view, natural size.

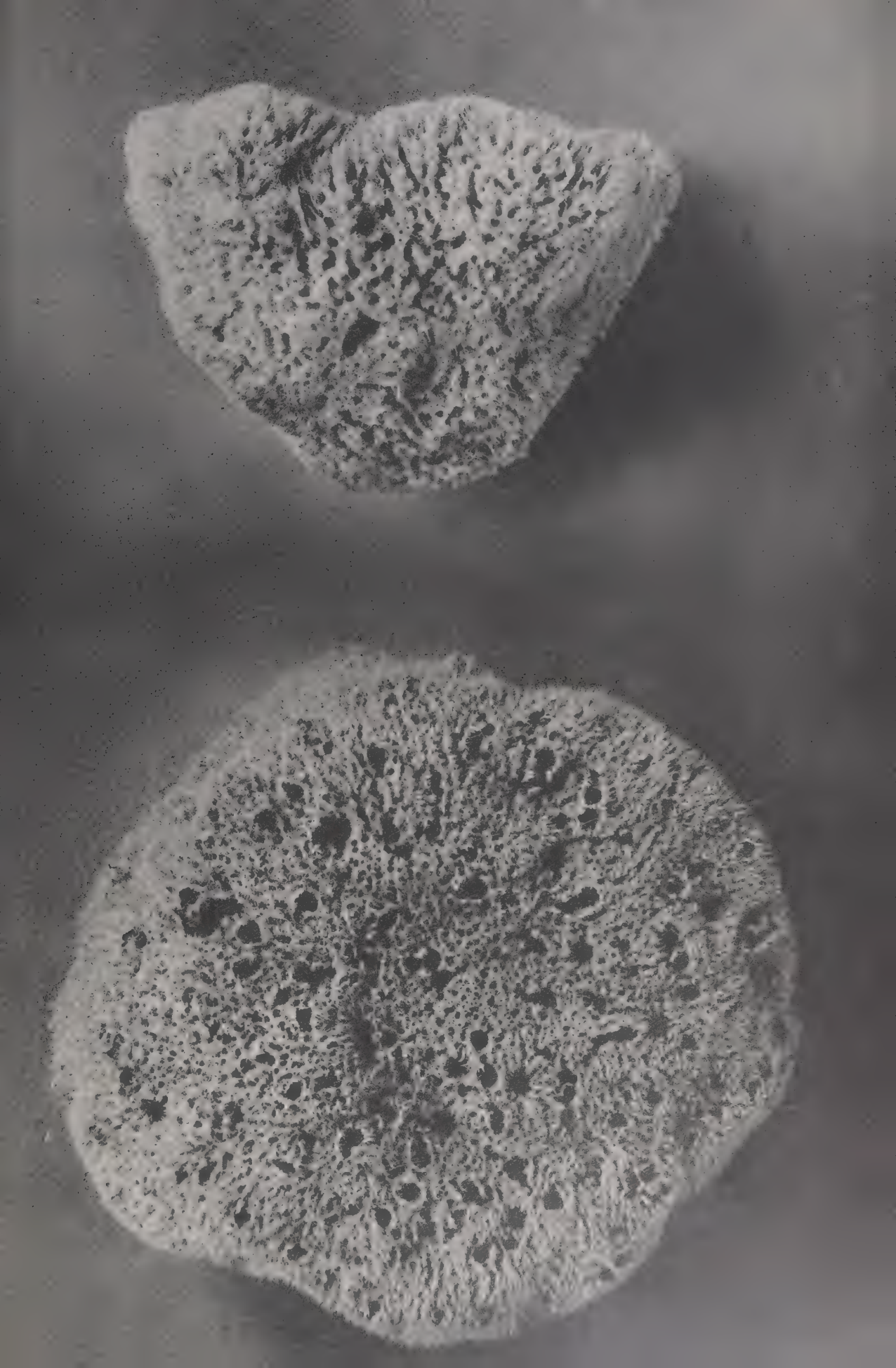

Plate LXV

Honeycomb sponge, Mediterranean Sea. Natural size.

Plate LXV

Horny-comb sponge, Mediterranean Sea. Natural size.

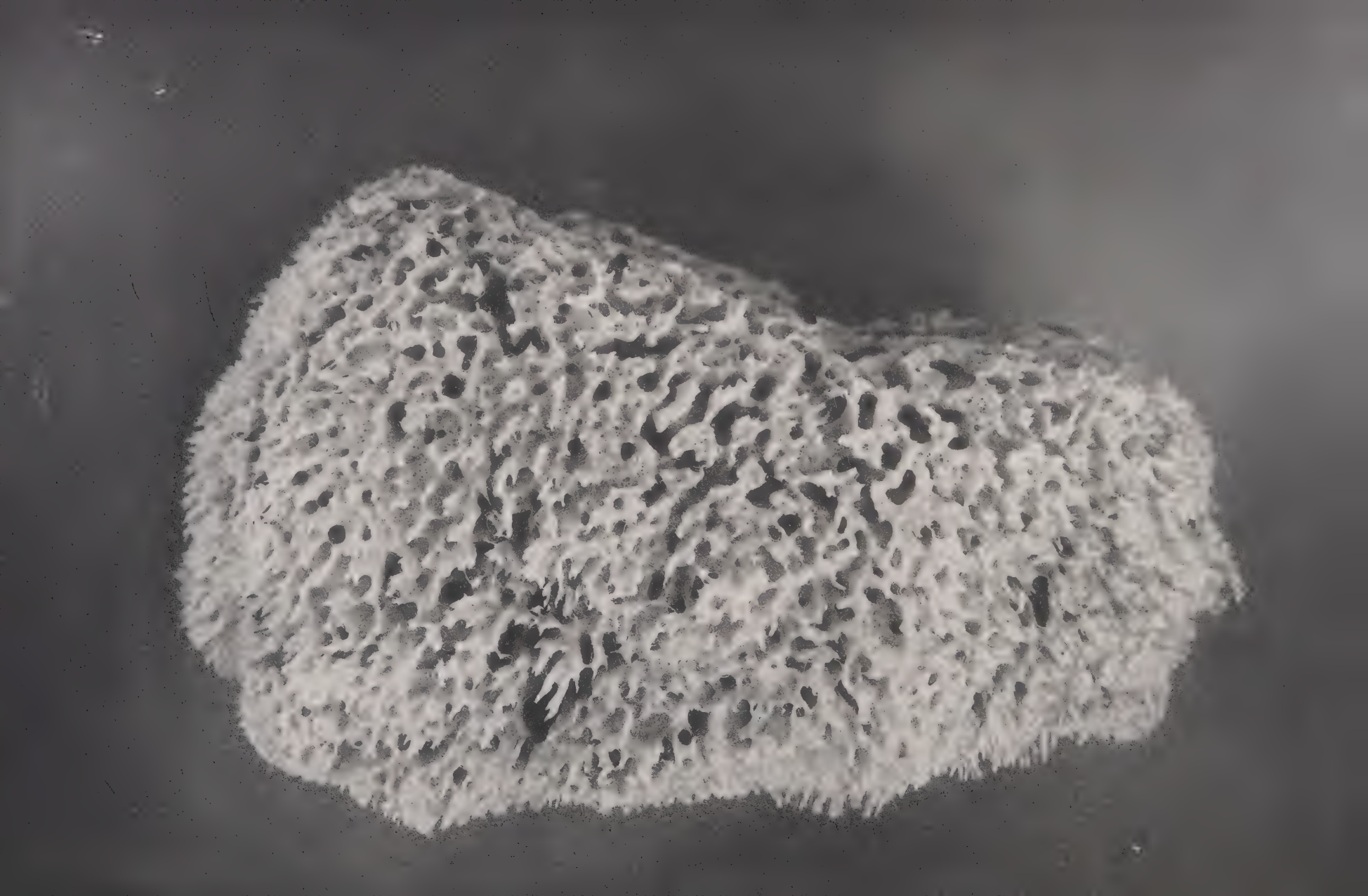

Plate LXVI

Elephant-ear sponge, Mediterranean Sea. Natural size.

Plate LXVI

Elephant-ear sponge - Mediterranean Sea. Natural size.

THE ABUSE OF THE SCAPHANDER IN THE SPONGE FISHERIES

By Ch. Flégel

Member of the Austrian Fishery Society, Vienna

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 28, 1908

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THE ABUSE OF THE SCAPHANDER IN THE SPONGE FISHERIES.

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[Translated from the German.]

I have the honor to report to the Fourth International Fishery Congress in Washington the unfortunate condition of the sponge divers of the Mediterranean Sea and the Gulf of Mexico. I do this with the well-founded hope that I shall meet here the active sympathy these sufferers so badly need.

A condition of this sort, of course, never arises without a precedent abuse or evil, and this rule is borne out in the sponge fisheries. The evil in this case lay and lies in inordinate greed of gain, uncontrolled by law, unchecked by any national regard for the general weal. Filled with this greed, which stops at nothing, men found it good forty-two years ago to adopt for the fishing of sponges the diving apparatus invented for quite other purposes. Although death and illness have ensued, these people continue this abuse at the present time so far as they are permitted. It is true that they did not succeed in winning the whole world over to their method; they met rather with strong resistance from their own compatriots, and thus a hot struggle began which has not yet ended, though fortunately the evil has lost ground before the good.

While in the island of Kalymnos in 1892, I accidentally learned of the sufferings of the sponge divers by asking a cripple the cause of his condition. The evils and abuses disclosed by his reply and confirmed by subsequent investigations of the subject led me to dedicate myself to the cause without in the least realizing that it would absorb years of my life.

The sponge fishermen everywhere lived in health and happiness so long as they gathered sponges by means of the three time-honored methods, hygienic and consistent with the public welfare; i. e., by means of diving naked, and by fishing with the hook and the dragnet. Since the scaphander was introduced in Greece and Turkey in 1866 numerous evils have befallen these formerly well-conditioned fishing people. There have been frequent cases of sudden and premature death, as well as of chronic diseases, worse than death, of youths

and men; a correspondingly large number of widows and orphans without means of livelihood, with the worst of consequences to the high morality of former times; fading girls on account of lack of marrying men; lack of work for many on account of the scarcity of sponges due to the destructive fishing; pauperism and emigration on account of the general misery—in short, a social disintegration of the worst kind. The suffering people sought relief in vain for twenty-six years, unable to make their protest heard or to obtain assistance in their struggle. The various governments in whose power it lay to remedy the evil were slow to recognize it, and it has been only by unremitting effort that action has been secured. Most of the Mediterranean countries, and also the United States, have within the past decade taken measures of prohibition or relief, but there still remains in many localities much to be desired.

METHODS OF SPONGE FISHING.

Sponge fishing by the three good methods had been an industry for centuries, especially in the eastern basin of the Mediterranean Sea. Sponges were found in great abundance before, both in shallow and deep waters, the fishermen, especially the naked divers, obtaining a good profit. The rowers were taken from neighboring localities, and youths and men, up to advanced age, were engaged for naked diving or the manipulation of the five-pronged hook and the dragnet. Whole fleets of small, excellent sailing vessels with naked divers departed to the East every spring after Easter, to the harbors of Syria, to the islands of Kalymnos, Syme, Chalke, and Kastelloriso; and other sailing fleets, with the five-pronged hook and the dragnet, left Tschesmé, Halikarnass, Hydra, Kranidion, Hermione, and Salamis, the village of Crappano in Dalmatia, the harbors of Italy, Tunis, Florida, Cuba, and the Bahama Islands. Healthy and jolly crews returned in September, from the coasts and the banks of the Mediterranean Sea and the Gulf of Mexico, with a rich harvest of sponges to sell to the local merchants for exportation.

The inhabitants of some of the islands and coasts of the Ægean Sea have from early generations been excellent divers, and were skillful also with hook and dragnet. The divers of Delos were famous in antiquity; those of Kalymnos and Syme are so to-day.[a]

The naked divers descend to the considerable depth of 75 meters and remain under water from 1½ to 2 minutes, a few even 2½ to 2¾ minutes. In a quest by the commander of a Russian gunboat in the harbor of Suda on August 10, 1907, one of several divers proved to be the best of them by remaining under water 2 minutes and 5 seconds at a depth of 17 meters, moving about hurriedly. In

[a] Herodotus mentions in Urania (chap. 8) the celebrated diver Skyllias of Skione. The sponge is mentioned by Homer in the Odessey (song 22, verse 455) and by Æschylus in Agamemnon (verse 1,329).

order to reach bottom the more rapidly, the diver grasps in both hands a flat block of white marble weighing from 14 to 16 kilograms, holds it in front of him, and jumps from the side of the vessel head downward into the spray, while a rope, passing through a hole in the stone and fastened also by means of a cord to the right wrist of the diver, follows him into the sea. Scarce touching the ground with his toes, the diver places the stone under his left arm, tears off the large sponges, and places these in a net fastened to his neck and waist. The crew of a sailing vessel with naked divers consists of 5 to 7 divers and 2 rowers. The only danger threatening the naked diver is the attack of a shark, but he does not consider this eventuality, as it is a very rare one.

The second mode of gathering sponges is by means of a five-pronged hook of iron, weighing from 2 to 2½ kilograms and fixed to a handle 9 meters long. Each bark of the Ægean Sea carries 4 to 6 hooks, 3 of which are bound together and braced end to end by 2 smaller handles of 2 meters each, making a combined length of 27 meters. For still greater depths, up to 45 meters, the sponge fishermen of the Ægean Sea use a five-pronged hook 1 meter long and weighing 12 to 15 kilograms, which is let down on a rope. The handles of the hooks of the Italian fishermen and the fishermen of Crappano in Dalmatia reach a length of 18 meters, while those of the Italians were, some sixteen years ago, only from 4 to 5 meters, according to the "Condizioni della Marina Mercantile Italiana," 1892. The crews of hooking vessels number from 2 to 5 men, one manipulating the hooks, the others rowing and assisting. Two men per bark are found only among the crews of Crappano, the crews in Italy, Tunis, Greece, and Turkey numbering 3 to 5 men. The sponge fishermen of Crappano, in order to be able to see the bottom of the sea more easily, pour oil on the surface of the water to render it smoother. A more practical and cheaper method is that of the fishermen of the Ægean Sea, who use for this purpose a special apparatus consisting of a tin cylinder with a glass bottom. The smoothing of the surface by a slight pressure of the glass bottom of the cylinder allows the eye to examine the bottom of the sea better than does the use of oil.

The third method of gathering sponges is by means of the dragnet, which is fastened to a rectangular frame 4 to 7 meters long and 0.35 to 0.45 meter high, and is dragged by means of three ropes joined to a heavier rope. The part of the frame lying on the ground is of iron and weighs 20 to 30 kilograms; the three other parts are of wood. The net has a depth of about 3½ meters and its meshes are 8 centimeters square. A sailing vessel equipped with a net is of 4 to 40 tons, and has a crew of 3 to 6 men, though the larger sailing vessels from Torre del Greco have more. The dragnet takes sponges at a depth of 120 meters, although not frequently. As it needs, for one thing, a flat sea bottom, and for another wind for the sails and room for maneuvering, it is evident that this work takes

place far from the coast in deeper water—taking up, it is true, all that lies in its path, but this is what would otherwise be left to die off, as no other means can reach the depths at which the dragnet works. The clamor against this apparatus on the ground that it harms schooling fishes is an exaggeration, but some countries, as the United States of America and Cyprus, have forbidden the use of it. This is regrettable, for thousands of people live by this mode of sponge fishing, without harm to themselves or others.

The fourth mode of sponge fishing is by means of the scaphander, or diver's suit, in which the sponge fisherman may descend to greater depths than the naked diver, and may secure great numbers of sponges not otherwise obtainable. The sailing vessel equipped with such an apparatus takes on board 4 to 10 divers and 8 to 12 sailors, and is always accompanied on long expeditions by a second sailing vessel, to carry provisions and to receive the sponges. The equipment of such an expedition for a summer's cruise of seven to eight months along the coasts of Africa costs 30,000 francs, that of a sailing vessel with naked divers 3,000 francs, that of a bark with the five-pronged hook 2,000, and of a sailing vessel with the dragnet 1,500, with the exception of the big vessels of Torre del Greco, the equipment of which is always more expensive.

EVILS OF THE SCAPHANDER.

The scaphander is in itself a splendid invention and very important and useful in submarine work at small depths, but its abuse in sponge fishing is equally harmful to the divers, the sponge grounds, and the economic welfare of the state. The diver in the apparatus may work without risk at a depth up to 16 meters, although accidents happen at smaller depths, as demonstrated by practice and as stated by Professor Katsarâs.[a] But at the greater depths of 16 to 75 meters, to which the unhappy diver is often forced to descend, the air, which is being driven down to him by two strong men by means of a pump, is correspondingly compressed in order to withstand the pressure of the water, which increases with every inch. This pressure hermetically fastens the rubber garment to the lower extremities of the diver, driving the blood continously toward the heart and head. The air breathed by the diver in the apparatus, saturated with carbon, penetrates into the blood through the lungs, renders it frothy and clogs the small vessels with bubbles, causing local obstruction and impediment of the circulation.

The degree of harm depends upon the depth to which the diver descends and the time he passes under water, then on secondary conditions, as colds, a heavy meal before diving, and fatigue. The disease of the divers, which is of

[a] In his excellent work "Recherches cliniques et expérimentales sur les accidents survenant par l'emploi des scaphandres," Paris, 1890, p. 292–293.

but one nature, is protean in its manifestations. It affects mostly the spinal marrow and the brain, the most important life centers, but appears in the most varied forms, as hemorrhages, stomach troubles, articular rheumatism, complete or partial lameness, lameness of separate limbs, fainting, vertigo, vomiting, dumbness, deafness, madness, brain stroke, heart stroke, hemorrhages of the brain, gangrene, loss of the finger nails, and frequently death, which is relief to these unfortunates. It should also be observed that the offspring of these divers have a weak constitution, especially of the nervous system. It is only if the diver is slightly attacked by the disease and immediately discontinues his work and subjects himself to treatment that it is possible for him to regain his health. Otherwise he is doomed to die prematurely, or he limps through life on crutches, or spends long years in bed covered with wounds. If the air-supply tube of the apparatus is punctured the unfortunate diver is immediately squeezed to death by the pressure of the terrible mass of water, which had received until that moment the necessary counter pressure from the air laboriously pumped down. His head grows black and swells so that it can not be pulled out of the metal helmet. It must, consequently, be detached from the body and cut to pieces before being removed. The body is lowered to the bottom of the sea in a sack weighted with stones, or it is buried on the coast. Soon after another diver assumes the helmet which but shortly was covered with the blood of his comrade, and goes to meet the same danger, like a gladiator of ancient Rome.

Since the dreadful consequences of the abuse of the diving apparatus are so evident, it is astounding that this business has spread and lasted so long, and in spite of the protests of the population and of individual philanthropists. Five conditions, however, explain partly the extraordinary duration of so great an evil: (1) The abuse is practiced on the high seas and concerns poor fishermen of distant, isolated localities, from which, moreover, they are absent the greater part of the year. (2) The evil is not confined to one country, but appears in all the sponge-bearing countries of the Mediterranean Sea and some of the Gulf of Mexico; the sponge fishermen do not live in compact settlements but dispersed on islands, peninsulas, and coastal strips of these two great basins. Thus the question is an international one. (3) The owners and partisans of diving apparatus endeavor to influence the governments, the press, and public opinion by such means as concealing the terrible consequences of this abuse or by excusing them. (4) There is a lack of official or private statistics on the mortality and diseases of divers using the diving apparatus and on the harm done by the apparatus to the sponges in respect to their reproduction. (5) There is a lack of responsibility on the part of harbor masters or captains for the death or illness of a diver; nor is there in

the countries where these divers live, i. e., in Greece and Turkey, any insurance on their lives, or in case of illness due to the diving apparatus.

The diver is circumscribed by an evil circle from which he can be released only by a beneficent law prohibiting this mode of sponge fishing. Greed, bravado, and necessity sent the first divers into the scaphander at the instigation of the harbor masters and captains. Now, with premature or sudden death or chronic disease before him, the "machinist" (μηχανικός, the sponge diver working in the machine, μηχανή, is named by the Greek people) sells his health and life as dearly as possible. He is paid for a summer season of seven to eight months 2,000 to 3,500 francs. This, however, he soon spends, as he is tortured by a craving for enjoyment, as a man condemned to death or with thoughts of suicide. The high wages of the divers, moreover, are often accompanied by rough treatment. They desert, and the harbor masters and captains punish them for it as long as they can by the exaction of high percentage, of extraordinary returns in sponges, of inordinately high prices for the provisions delivered to their families, or by pitilessly requiring them to dive to too great depths, where they meet death or disease as a result.

The sponge-fishing population of the Ægean Sea, Greeks and Albanians, was a religious one without being fanatic or superstitious. They maintained faithfully the ancient simple rites and customs, and their mode of life was honorable and patriarchic. But what a change has come in all this since the abuse of the diving apparatus shook to the depths the moral and material life of these brave fishermen! Both those who use and those who do not use the diving apparatus have fallen into misery, but the worse fate and the responsibility for the evil has befallen the users. A victim of premature death, or of chronic diseases worse than death, the unfortunate diver seeks in his affliction to forget his terrible fate in amusement and profligacy to-day, for to-morrow leaving his aged parents or his young wife and small children in misery; or still worse, he is left to share this misery with them as a cripple; or, by the height of misfortune, he limps through his native place or a foreign land as a beggar, if he is not so crippled as to have to be carried in a cart. The harbor masters and captains, as already stated, bear no responsibility for the frequent accidents, and with no provisions of insurance for cases of disease and death, the entire burden of the misfortune falls upon the family and the nearest relatives of the victim. The sponge trade likewise has for years suffered from the high prices of the sponges, a natural consequence of the destruction and scarcity caused by the diving apparatus and by the expensive hire of the divers.

Specialists have for some time been studying and publishing the results of their observations on the frequent and varied diseases and the numerous cases of death from working in compressed air, and more recently especially among

the sponge fishermen working in diving apparatus. Paul Bert, Guérard, Febvre, Feltz, Bouchard, Petit, Couty, Chabaud, Vivenot, Schultze, Saeger, Leyden, Pierre Marie, Rameaux, Bucquoy, Hermann von Schrötter, Kononoff, and others have written on the general subject, and Paul Bert, Leroy do Méricourt, Gal, Lampadarios, Kotsonopoulos, Parissis, Tetsis, Charpentier, Katsarâs, Savvas, Livadâs, and the Greek naval officer Melâs have treated it with especial reference to the divers. It will be to the purpose to cite some of these writings.

Michael Katsarâs, professor of nervous diseases at the University of Athens, published in 1890 the already mentioned work on diseases of divers,[a] which were not sufficiently considered by the governments of the interested countries.

Katsarâs observed and described 62 cases of diseases of divers, and made experiments with the diving apparatus on dogs. I refer to his book all those who desire better acquaintance with the subject. The celebrated scientist lives in Syme, one of the principal seats of abuse of the diving apparatus, and is, consequently, well acquainted with this evil.

Katsarâs limits himself to purely scientific demonstrations without uttering any cry of horror. After having described all the forms of the diseases, he indicates the means of curing the slighter ones. These treatments, however, demand so much time that only persons in prosperous circumstances can take them, and not divers weighted down by debts. Katsarâs gives the following advice as to what the diver must do to avoid disease:

(1) Regulate the duration of the sojourn under water according to the depth, as one hour at depths of 10 to 15 fathoms, one-quarter of an hour for depths of 15 to 20 fathoms, ten minutes in depths of 20 to 25 fathoms, five minutes in depths of 25 to 28 fathoms, 3 minutes in depths of 28 to 30 fathoms, and one minute in depths of 30 to 32 fathoms.

(2) Rise very slowly, stopping for one minute after each 2 fathoms.

(3) Avoid consecutive diving by the same person.

(4) Do not dive too deep.

(5) Do not dive while afflicted with a cold.

(6) Have the intestines empty before diving, and eat only in the evening after the completion of the work.

(7) Avoid fatigue.

What would become of pecuniary profit, which is the most important consideration in each trade, if the seven prescriptions of Katsarâs were followed? Of these the most important is the fourth, and this according to his own words it is not possible to follow. Katsarâs himself says:

Of these the fourth precaution can not be considered; to forbid the divers to descend too deep would be to forbid them their trade, for a sufficient quantity of sponges can not be found at small depths.

[a] "Recherches cliniques et expérimentales sur les accidents survenant par l'emploi des scaphandres," Paris, 1890.

This is the only passage, but a very important one, in Katsarâs's work, which indicates that the diving apparatus is likewise very harmful to the reproduction of sponges.

Katsarâs gives other specific advice:

> I advise the affected divers to dive daily for two or three months to a depth of 8, 10, and 12 fathoms, staying under water from fifteen to thirty minutes; and to vary the treatment by compressed air for one month by first cautiously eliminating the pressure, and then resuming it again, etc. * * * The authorities of these sponge-fishing islands should therefore establish small hospitals on the seacoast in order to introduce the systematic treatment with compressed air by means of the diving apparatus. Each small hospital ought to possess 2 or 3 apparatuses for this purpose, and other treatment should be included.

Can anything be more obnoxious and futile than this system? Rendering men ill in order to cure them, and recommending to them a trade with such precautions that it must cost more than it would yield? Katsarâs has likewise failed to give statistics of deaths; he contents himself with far too mild a statement when he says on page 2 "No year goes by without at least 10 dead."

Katsarâs wrote as a clever physician, leaving others to apply his results. These others are in the first place the authorities of the localities and countries in which the sponge divers live, and in the second place the authorities of the countries in which the abuse is practiced, and unfortunately they pay no attention to the work of the great scientist. It has therefore brought scarcely any aid to the unfortunates to whose weal it is dedicated. Only by enforcing the important logical deduction from the excellent work of Katsarâs can the solution of this question and the salvation of these unfortunates be brought about. The diving apparatus in sponge fishing must be prohibited, a thing which has now taken place in some countries, thanks to the pains we have taken.

ATTITUDE OF THE GOVERNMENTS.

As already stated, my work in behalf of the sponge divers began with my visit to Kalymnos in 1892. My plan was to appeal to the governments of each of the sponge-producing countries of the Mediterranean Sea, beginning with the smaller and nearer ones and going to the larger and more distant, and including countries without sponge fisheries, but with sponge beds, as well as those with sponge fisheries with and without machine diving. According to this programme, after Kalymnos came Samos, Crete, Cyprus, Egypt, Tunis, Italy, Austria-Hungary, Greece, and Turkey, all of which except Tunis I visited in person. It will be best to discuss first the conditions in Greece.

GREECE.

The sponge fishermen of Greece live at Kranidion, of 8,000 inhabitants, and Hermione, of 2,000 inhabitants, on the Argolic Peninsula, at Hydra with

7,000, Spetzæ with 6,000, Ægina with 8,000, and Salamis with 3,000 inhabitants; with the exception of the Æginetes, they are all Albanese. There are no naked divers in Greece; the sponge fishermen of Kranidion, Hermione, and Salamis use the hook and the dragnet; those of Hydra use the diving apparatus, which was introduced in Greece in 1866 by several men from Nauplia for the sponge fishermen of the neighboring localities of Kranidion and Hermione. After these machines had brought death to several men and had crippled others, also had cost a great deal of money, they were voluntarily relinquished in the two latter places. A new attempt to introduce them in Greece was made in 1882, however, after they had been operating without interruption in Turkey. This occurred at Syme and was more successful financially, since it was in direct communication with the world market of London and especially because much less heed was taken to spare the human victims which must be sacrificed if financial success is to be obtained in this deadly trade.

The evil made thus great progress notwithstanding the protests of the people from time to time, the terrible abuse growing at last into a recognized industry. The fearful consequences were excused by citing that in other industries, as in mining, accidents happened likewise. It was not taken into account that in the mines it is the natural conditions that bring about accidents, while in sponge fishing with the diving apparatus men make deliberate choice of this over the three safe modes of fishing, because by this means they can gain money more rapidly, the sacrificing of human lives, the misery of their neighbors, as well as the future of the sponge fishery being unheeded, and nobody held responsible for the evil.

The Greek Government, however, does not ignore the cause of the sponge divers. On the contrary, as appears from various official reports, the evils of the business are well recognized.

The ministry of war published on April 12–24, 1896, a circular on the precautions to be taken by machine divers, and sends out every summer the dispatch boat *Kreta*, sometimes also a second war ship, to the coasts of Africa from Derna to Sfax for the purpose of supervising the sponge fisheries, of supplying the fishermen with drinking water, and of lending the necessary assistance in cases of illness. This ministry also founded in April, 1904, at the recommendation of Her Majesty Queen Olga of Greece, a hospital for seriously diseased divers at Tripoli, the lighter affections to be treated on board the *Kreta;* and it published in March, 1904, the very noteworthy report of Constantine Savvas, member of the board of health, professor of hygiene at the University of Athens, and physician to His Majesty King George of Greece, on the diseases of the divers and remedy for the evils existing.

According to the data furnished by the Greek Naval Office and by private individuals (Savvas, p. 10), Hydra sent out, during the summer season of 1903,

171 vessels with 1,370 sponge fishermen, of which craft 36 were sailing vessels equipped with diving apparatus, 342 divers, and 667 sailors; 15 were sailing vessels with the dragnet and 80 fishermen, and 70 were barks equipped with hooks and 281 fishermen. Ægina sent out 40 sailing vessels with the diving apparatus, of which 24 were accompanied by another sailing vessel, with 214 divers and 508 sailors. According to the harbor master of Spetzæ this island put out in that year 8 sailing vessels with the diving apparatus, 43 divers, and 80 sailors. Kranidion sent out 52 barks carrying hooks, with 162 fishermen, and 21 sailing vessels with the dragnet and 93 fishermen, moreover 2 vessels with 24 sailors carrying supplies to the fishermen on the coast of Africa. The number of 12 sailors on each of these vessels is extraordinarily large, and Hermione is not mentioned by Savvas. The total of the above figures is 318 vessels with 2,494 men, of which 134 carried 599 divers and 1,173 sailors, 122 carried hooks and 443 fishermen, 36 carried the dragnet and 173 fishermen, 24 were escort of the diving vessels and had 82 sailors, and 2 were packet boats with 24 sailors. According to the commander of the *Kreta*, Stamatios Vuduris, the fishermen flying the Greek flag gathered in 1902 120,000 to 130,000 oka, or 153,600 to 166,400 kilograms, of sponges, valued at 5 to 5½ million drachmas.

From the data furnished by the Greek naval physician, George Sphinis, who served on the *Kreta* from 1900 to 1903, Savvas gives the following statistics:

> Under the eyes of the officers of the *Kreta* in 1900, 12 divers died, 228 fell slightly ill, 34 fell seriously ill. In 1901, 396 fell ill, 34 were treated on the *Kreta*, and 5 of these died. In 1902, 3 died on the *Kreta*, 232 fell slightly ill, and 23 gravely ill. In 1903, 56 sick were treated on the *Kreta*, of which 9 were completely cured, 17 improved to such an extent that they could do some work, while 27 improved, but needed after treatment. Three died.

Savvas observes:

> The number of divers treated on the *Kreta* seems small in comparison with the cases of illness in previous years. This is due to the fact that the captains of the sponge vessels are distrustful toward the war-ship on account of its rigorous supervision and would not report their sick, going only so far as to ask for remedies.

But do not the men asking for remedies avow that there is at least one sick on board, and has not the commander of a war-ship the power to seek out the sick on board the small vessel should he earnestly desire it?

Savvas says further that Paul Bert had found that about 30 Greek sponge divers died every year. Katsarâs reduces this already inadequate figure to "at least 10," while Sphinis states that the number seen by him and the officers of the *Kreta* were 12 in 1900, 4 in 1901, 3 in 1902, and 2 in 1904. Savvas, however, observes, quoting official witnesses for corroboration, that "the number of deaths among the sponge divers is much larger." And the commander of the *Kreta*, Stamatios Vuduris, says that 60 divers had died at Bengazi and Derna in 1901. In the Great Desert there was found a sack containing the bodies of two divers.

The commander of the *Kreta* in 1903, Petros Zotos, obtained under oath names of 24 divers deceased in that year. This commander learned, moreover, from a reliable source, that 40 other divers, whose names he could not get, had died. He is of the opinion that of the 900 divers who work under the Greek flag in 140 scaphanders more than 100 died within the period of one summer cruise (from March to October), that the others all but a few "are either crippled already or will soon be so and absolutely incapable of any other work." My experience of many years confirms the opinion of Captain Zotos.

Savvas republishes in his report the already mentioned circular of the Greek Naval Office of April 12–24, 1896, on the precautions to be taken by the divers. This had never been enforced, a fact which has made the Greek Government since 1900 detail a war-ship each summer for the protection and assistance of the sponge fishermen. Savvas finds even this measure insufficient, however, without a special law, observing that—

> The measures of the rapidly succeeding governments have unfortunately but a very small effect upon the sponge fishing conducted with diving machines. It is absolutely necessary to take more effective and thorough measures, and such ought to be inaugurated by a special law for the purpose of limiting the evil.

The measures recommended by Savvas are divided into three classes, (I) financial, (II) administrative, and (III) sanitary.

I. The captains of sponge-fishing vessels borrow, at very high interest, a considerable sum which is to be paid back to the lender at the end of six months. In order to obtain sufficient sponges to be able to pay back the borrowed sum with the interest and, moreover, to support themselves and their families, they employ a comparatively small number of divers, who must work very hard and risk every danger. The captains exhibit a change of attitude as the fishing season advances. Until their indebtedness has been covered by the number of sponges obtained, they spare the divers, but after this the latter are driven to extremest effort for the captain's personal gain before the end of the season shall have come. Savvas proposes, accordingly, to decrease as much as possible the borrowed sum and the interest, which amounts each year to from 24 to 36 per cent. The prices of provisions for the crew and for the vessel's supplies are exorbitant, but the captain is obliged to accept; otherwise he does not obtain the necessary loan. Savvas would, therefore, as a first financial measure, decrease the interest to 10 per cent and 12 per cent, and allow the captains to purchase the provisions and other necessaries where most advantageous to them. Savvas does not discuss the question of source of the capital for the enterprise, whether to be supplied by banks or otherwise; but he deplores the advancing of money by the captains to the divers, since the latter spend it in orgies which are harmful, not only because the money is uselessly spent, but also because the physique of the divers, weakened by dissipation, is much more readily the prey

of disease. By this advance, moreover, the diver is placed in complete subjugation to the captain, who makes him work even when he is ill. As a second financial measure, Savvas would change the advance pay into a monthly salary. As a third, he proposes the founding of a relief fund for the divers, to which all captains and divers ought to contribute. From this fund assistance would be given to the widows and orphans and to the sick and disabled divers. The school for divers and the hospitals for the latter would likewise be maintained from the proceeds of this fund.

II. The first administrative measure proposed by Savvas is the founding of a diving school at Toros, Hydra, or at the navy-yard of Salamis. A diploma from this school would be demanded for permission to follow the calling of diver or to be a captain of a sponge-fishing vessel. Only when all the men are trained will it be possible, according to Savvas, to place upon the captain the responsibility for violating precautionary measures and not now when he acts in ignorance. The school would be under the direction of a naval officer, after the latter, if possible, has visited the diving school of the Russian fleet in Cronstadt, which is considered a model. A naval physician would likewise be detailed to this school, after having undergone a course of special studies on this subject in order to learn the elementary anatomical and sanitary knowledge in this domain. He would be present at the practical exercises of the students, to give immediate assistance in case of accident and to subject divers suffering from a chronic disease to a regular treatment, and if possible a hospital would be erected in the vicinity of the school. A course of one month should be sufficient training for the divers.

Savvas's second administrative measure is to subject the sponge-fishing vessels to a thorough examination before their departure, not only to ascertain the condition of the divers, but also to inspect the diving apparatus, the air pump, the rubber tube, the clothes of the diver, the manometer. Men suffering from lung and heart diseases should not be allowed to work as divers, nor should neurasthenic, weak, or anæmic persons, those suffering from chronic diseases of the ear and nose, those who are very lame, nor men under 20 and over 40 years of age. This inspection ought to be held by a commission consisting of a naval officer as president of the board, a naval physician, and a naval engineer, who should go in person to the point from which the fleet of sponge-fishing vessels is to take its departure. The board of inspectors should be authorized by a special law to issue permit and ship's papers to each vessel fulfilling the above-mentioned conditions, which permit and papers are at present issued by the authorities of the port; also to prohibit, by force if necessary, the departure of a vessel not fulfilling the conditions, or of a diver who does not possess the qualifications demanded.

The third administrative measure proposed by Savvas is to insure the correctness of the ship's papers, which heretofore have been supervised very carelessly by the port authorities. The captain should be compelled to keep his records with the greatest exactitude and to report each change in his crew to the nearest port authorities or to the commander of the cruising war ship. Upon returning to his native port, he must render account of the health of each of his crew individually, as well as of deserters and deceased. The harbor master must then make to the Naval Office a detailed report on the cruise.

Savvas recommends as a fourth administrative measure the supervision of sponge fishing along the coast of Africa by one or two men-of-war, which has been done since 1900. Savvas urges, further, that the naval commanders be empowered to take more active measures, to impose small fines for the violation of regulations, and even to deprive the captains of their permits.

As a fifth administrative measure Savvas recommends an exact regulation of the duties of the captain and the master of the divers in regard to the latter, as well as of the mode and duration of the work and an express definition of the responsibility of the captain and the master for each violation of regulative measures, thus to prevent all excuses based on ignorance.

The sixth administrative measure is the imposition of heavy punishment on the captain and the master for the violation of any regulation, and Savvas cites articles 300, 301, and 310 of the Greek penal code and articles 222 and 230 of the German, in force in the diving service of the German fleet. He does not deem the articles of the Greek penal code sufficient, however, and expresses the opinion that they ought to be made more rigorous by new legislation applying especially to the diving business, for only then could a limit be put to the requirements of the captains. The harbor masters and the commanders of the supervising war vessels should have authority to impose punishments upon the guilty, for too much time would be necessary for action in such cases by the court or by the Naval Office, and the effect of the punishment would be weakened.

III. The following are the sanitary measures recommended by Savvas:

(1) Perfect health of the diver when entering upon his work.

(2) Slow descent to the depths of the sea.

(3) Regulation of the duration of the sojourn of the diver under water by the depth, according to Katsarâs.

(4) Slow ascent from the depth, according to Katsarâs, Silberstein, Méricourt, and Kononoff.

(5) Prohibition of continued diving by the same person, quoting the opinion of the inventor of the most popular diving apparatus, Denayrouze, that the duration of work for a diver in this apparatus should never exceed

2½ hours daily and, according to others, that the diver should dive but once a day.

(6) Avoidance of diving during a cold or with a full stomach.

(7) Avoidance of fatigue, of use of liquor, of fasting.

(8) Presence of remedies and means for first aid on each vessel, as (*a*) compressed-air treatment when the diver falls ill, a thing which Savvas himself admits is impossible, since there is room for only one diving apparatus on each vessel, and the latter serves for the work and not for curative purposes; (*b*) breathing of compressed air; (*c*) establishment of hospitals on the African coast and in Greece; such a hospital was founded in Tripoli in April, 1904.

Savvas says in chapter 8, under the heading "The result," that about 2,600 men are engaged in sponge fishing in Greece alone, that among these there are 636 machine divers on 134 vessels with 1,218 sailors, that according to the reports of the commanders of the *Kreta* at least 60 to 100 divers die each year, and that so many fall ill that four-fifths of them are more or less severely crippled, a fact that renders their work much more arduous or often completely incapacitates them. The remaining sponge fishermen, of whom those using the dragnet form the minority in Greece, while the naked divers form the majority in Turkey and are the only ones in the other countries—these, Savvas observes, suffer no harm. Why, then, does not Savvas state the conclusion to which every impartial person must come, that the harmless modes of sponge fishing should be encouraged and the harmful prohibited? He does imply this conclusion in the following statement:

> If the execution of these measures is for one reason or another impossible (and it is impossible, for the profits, which are the principal incentive of every trade, would be lost), then should the prohibition of machine diving be considered, not only for the salvation of a large number of persons from death and disease, but also for the honor and good name of the country.

Regard for the life and health of the divers and for the good name not only of Greece but of all countries interested in the sponge fisheries, I share fully with Savvas; but I am amazed at the time required by most theoreticians, of whom Savvas is one, for recognition of the fact that no advance can be made by the execution of even a part of his measures—that their enforcement imposes the prohibition of machine diving. It is the same end at last, after all is said and done, i. e., the actual prohibition of the scaphander.

While Professor Savvas was writing his report, the Naval Office detailed in January, 1904, a board, consisting of 12 members, to which belonged Savvas and deputies from Parliament from the sponge-fishing districts as well as naval officers, for the purpose of working out a project of law to govern sponge fishing with diving machines. The board finished its work within a month. The drafted law contains all that Savvas demands in his report, but has not been

once brought up in the Chamber of Deputies during the four years that have elapsed since then. It may be gathered hence that the partisans of the diving machine, wishing not to be molested, know how to hinder the presentation of the question before the Chamber, and without the vote of the Chamber the execution of the measures is of course impossible. Thus, then, the well-meant regulations are absolutely unimportant because they are impossible of execution; and they are worthless and impossible of execution also because they cost more than the industry yields—and this is the worst to be said about an industry. This wretched business is profitable now because all responsibility, all burdens, all the suffering of it, can be shifted and because the two countries where it exists, Greece and Turkey, have indorsed it for forty-two years.

In January, 1907, the Greek Naval Office in Athens published the "Guide for Divers" by the naval physician, Dr. Spiridon Livadâs, and the naval lieutenant, Constantine Melâs. By the wish of Her Majesty the Queen of Greece, Livadâs and Melâs were detailed for a few weeks to the diving school of the Russian fleet at Cronstadt, in order to familiarize themselves with the innovations and improvements brought about in this work. Their "Guide" does not give any statistics of death in the sponge fisheries, but it reiterates the advice already given by Katsarâs and Savvas; and it has a highly suggestive title-page depicting a naked sponge fisherman lying on a bed in the hospital of Tripoli, his body covered with wounds, himself one of the numerous victims of the diving apparatus who died from gangrene after an illness of six weeks. This title-page, the short description of the sufferings of this victim, and the great number of precautions to be observed by the diver in order to avoid the grave danger threatening his life and health, are likely to frighten him, and thus this book renders a great service to the sponge fisheries. Not otherwise, however, can it prove of great benefit to Greek divers, for there is an enormous difference between the work of the divers in the navy, which is of great usefulness and harms nobody, and that of the sponge divers, who have to consider pecuniary remuneration and engage in work which causes the greatest harm to men and sponge resources.

Thus, as shown by the official reports quoted; by the fact that the Greek Government maintains the hospital ship *Kreta* in the interests of the sponge divers; by the fact that a hospital has been established at Tripoli at the instigation of Her Majesty the Queen; by the issuance of circulars and regulations from the Greek Ministry of War—by all these various actions the evils of machine diving are acknowledged in Greece. I have obtained the favorable consideration of the King and the cordial sympathy and aid of the Queen in the cause of these suffering subjects. The people themselves have given evidence of their need and of their appreciation of efforts for their relief. But the logical and

hoped-for result, the suppression of the evil by entire prohibition of the diving apparatus, is not yet accomplished.

KALYMNOS.

In Kalymnos results were at last obtained by the promulgation, in 1902, of an irade from the Sultan, which in the extent of its prohibitions exceeded the expectations of both factions interested. In execution the irade has, however, been defective. Provision was not made for the confiscation of diving machines nor for their exclusion from Turkish import and export. And in spite of the prohibition, a considerable number of Greek and Turkish sponge divers worked until lately in Turkish and Cretan waters without being prosecuted. They contended that they worked in neutral waters, since they fished at a distance of 3 maritime miles from the coast, where, according to them, everything was free to everybody. This interpretation of the neutrality of waters is absolutely arbitrary and sophistical, since it is the sponges that are here in question and not the waters, and since the sponges, with the banks on which they grow, even if 20, 30, and even more maritime miles from the coast, belong to particular states, generally to the one whose coast is the nearest. But even if the owner does not wish to protect his sponge banks or if he can not do it, as happened with Crete, on account of the lack of a revenue cutter, the wrongdoers need by no means be allowed to carry on illegal operations, even in neutral waters. Civilized nations are solidary in this respect and do not overlook such criminality, as was shown in 1905, by the four protecting powers of Crete, Great Britain, France, Italy, and Russia, and lately again by France in Cretan waters. The sponge fishermen following the three older methods of fishing are naturally displeased at the disregard of the prohibition, and there have been some disorders on this account in Kalymnos and Syme.

SAMOS.

The Duchy of Samos possesses good sponge grounds, but no native sponge fishermen, and by reason of its small size would be of slight importance in the sponge fisheries had it not been the first autonomic country to prohibit diving machines. This prohibition took place in 1898, and in 1902 was revoked, but in 1904 the law was again changed, prohibiting the diving machine and repermitting the dragnet, which in the meantime had been prohibited for an interval.

CRETE.

There are no sponge fishermen in Crete, with the exception of a few who allow themselves to be tempted to work on foreign sailing vessels in diving apparatus. But there are excellent sponges there, especially on the coast of

the eastern prefecture (Lasithi) and the islands belonging to it. Since 1898, the revenues obtained from licenses for sponge fishing fluctuated between 7,833 francs 40 centimes in 1903, and 26,360 francs in 1902. The naked divers and those using the dragnet paid in 1907, up to November of that year, 230 francs for each sailing vessel and since that date 250 francs, while the hook fishermen paid 90 francs, now 100 francs, for each bark. The working season in sponge fishing is considered on Crete from March 1 until February 28. The Cretan statistical data do not give, unfortunately, any information as to how many, whence, or on how many vessels sponge fishermen arrive, how many of them use the three proper modes of fishing, nor the quantity and value of the catch of each.

The first action against machine diving on the sponge banks of Crete was obtained in 1899, and consisted of a law of complete prohibition. The sponge beds flourished in consequence, and soon became a great temptation to the greedy machine divers of Greece and Turkey, who sought repeatedly, from 1901 to 1907, to have the law repealed. Failing in this they circumvented it by fishing secretly on the coasts of Crete on their return from the African banks, and in 1905 enlisted even a few Cretans in this illegal enterprise. I at once took steps in the matter, and had the satisfaction of seeing the four protecting powers—Great Britain, France, Italy, and Russia—send their war ships to seize the culprits. Unfortunately, however, proper punishment was not inflicted, and the situation became an open scandal. In government circles it was claimed that enforcement of the law was impossible because Crete owned no revenue cutter. But there were guilty Cretans who could have been apprehended without any revenue cutter, and the license fees from the sponge fisheries would have built a revenue cutter long since. The contention between the friends and opponents of the diving machines kept the question embarrassingly alive to the Government and Parliament of Crete, and finally brought about action in the fall of 1907, whereby a limited number (10) of diving machines were permitted for ten years to a syndicate under certain specified conditions. These conditions, however, were purposely made so difficult that no such syndicate could be found, nor ever can. Another provision of the law was for the payment of damages to the families of divers who died as a consequence of the use of the scaphander. Thus the law has been saved; but the lack of a revenue cutter in Crete is a disadvantage that calls for prompt remedy.

The cause of the sponge divers in Crete received a further signal support in 1908, when the French Government, at the request of the Cretan Government, ordered its war ship *Faucon*, stationed at Suda, to apprehend the sponge divers fishing illegally in the waters of Hierapetra, which are under French control. The *Faucon* captured 7 boats, with 80 men, from Kalymnos and Syme. The remainder escaped in a heavy gale, and three were wrecked, with

a loss of 25 men. The decisive action on this occasion of the Cretan Government has greatly encouraged the opponents of the diving machine, and has led to similar requests in regard to the sponge grounds of Turkey, Italy, Tunis, Cyprus, and the Gulf of Mexico. In any event, the governments of Greece and Turkey have before them the important duty, whether or not they forbid the diving machine in their own territory, to prevent their own subjects from violation of the laws of other countries. And such violation when it does occur should be punished by confiscation of the ship's papers for a year or more, and forever in case of repeated offense.

It will be noted from the foregoing that the position of Crete in regard to the sponge fisheries and her attitude in the present question is most important and worthy of admiration.

CYPRUS.

Cyprus likewise has rich sponge banks but no native fishermen. The harmless dragnet was long ago prohibited, but the diving machine was permitted until 1901, when, the authorities having been enlisted against this abuse, a law was obtained which remained in force for three years. In 1904 the partisans of the apparatus succeeded in obtaining authority for a limited number of diving machines, under pretext of work to be done in the harbor of Famagusta. The naked divers and hookers were driven away by the conditions operating to their hardship; and a plan for a colony of sponge fishermen, as in Egypt, likewise came to nothing, naturally, since it of necessity involved the discontinuance of machine diving. At the present time the Government of Cyprus leases to the highest bidder the privilege of using six diving machines in one and the other half of the waters alternately, a misstep which is the more astonishing in the face of the wholesome example of near-by Egypt.

TUNIS.

The Regency of Tunis has extensive sponge banks, and numerous sponge fishermen, about 1,500, on 400 barks equipped with hooks. A great number besides come yearly from Italy, Greece, and Turkey. I lack statistics for Tunis, however. At my solicitation the scaphander was prohibited in 1901, but unfortunately, notwithstanding the apparatus is termed "engin destructeur" in the language of the decree, enforcement of the prohibition has failed, through intrigues of the opposing forces.

TURKEY.

Turkey has the most and the best sponge fishermen, but unfortunately official statistics of the sponge fisheries are entirely lacking. The chief localities are Kalymnos with 18,000 inhabitants, Syme with 20,000, Chalke with 6,000,

Kastelloriso with 6,000, Halikarnass with 3,000, Tschesmé with 3,500, Aivali with 20,000, Moschonisia with 3,000, and Marmara with 2,000, also villages and cities of Syria. Before the introduction of the diving apparatus there were some sponge fishermen also in the islands of Patmos, Leros, and Telos. In Kalymnos, Syme, Chalke, and Kastelloriso all four kinds of fishing methods are represented, in Halikarnass and Tschesmé, only the dragnet; in Aivali, Moschonisia, and Marmora, only the diving apparatus, though in limited numbers; in Syria there are only naked divers. The first six places and the villages of Syria have always depended entirely upon sponge fishing for a livelihood. Since the introduction of the diving machine there has been a marked emigration, especially to Russia and the United States of America. The famous naked divers, who have inherited this skill from many generations of forefathers and have perfected it by practice, live at Kalymnos, Syme, Chalke, Kastelloriso, and on the coast of Syria.

A law prohibiting the scaphander was promulgated in 1902, but is not effectively enforced.

EGYPT.

I went to Egypt in 1901, after successful visits to Samos, Crete, Cyprus, and Tunis. I encountered considerable opposition, but a beneficent law was at length promulgated in the spring of 1902, to be followed in the autumn by a similar decree for the whole Ottoman Empire. The Egyptian Government has always shown great interest and care for its sponge fishermen, having founded a colony for them near the excellent harbor of Marsa Matruh, 160 kilometers west of Alexandria, and having also rigorously enforced the law by means of the coast guard.

In 1906 a rich new bank, extending 110 miles from Abukir and having a width of 1 to 3 miles in a depth of 20 to 60 meters, was discovered by some Italian fishermen, who found sponges in their nets. This El Dorado, known as the bank of Port Said, after a most successful cruise thither by a vessel from Syme, attracted sponge fishermen from everywhere. The sponges were of the finest quality, and conditions were most favorable, for the diving apparatus was entirely excluded.

In 1908, however, word began to be circulated that the Egyptian Government could not enforce its law outside the 3-mile limit. The sponge fishermen following the three good methods had meantime begun to assemble near Marsa Matruh, in Alexandria, where a fleet of 350 vessels with 3,000 men waited two weeks for decision from the Egyptian Government. Requests and petitions with thousands of signatures were of no avail. The advocates of the diving machine proved the more powerful, although they possess legal rights only in Greece. The Egyptian Government refused to assert control of the banks out-

side of the 3-mile limit, and the waiting sponge fishermen found themselves at once in competition with vessels equipped with diving machines and armed with rifles, revolvers, and sabers. A crew of naked divers from Kalymnos were fired upon, and in response to complaint of the captain the Egyptian Government apprehended 110 men with 9 diving machines 26 miles off the coast and brought them to Port Said. Instead of prosecuting them, however, and inflicting the punishment that was deserved; notwithstanding that arms and ammunition were found on board their boat; notwithstanding also that they were Turkish subjects and therefore liable to the laws of Turkey and Egypt against diving machines, they were allowed to depart, after twenty-four hours, in full possession of diving equipment, arms, and ammunition.

The hardship upon the original occupants of the sponge grounds was great. After paying their fees of 8 to 4 Egyptian pounds (200 to 100 francs) for permission to fish, they were driven away, and in Syria, whither they resorted, they must pay an equal fee. The banks of Port Said are thus, moreover, left at the mercy of the machine divers. I have appealed to the International Life Saving Congress, held at Frankfort on the Main, and now urge the International Fishery Congress at Washington to give support and sympathy to the unfortunate sponge fishermen who have undergone such loss this season at Port Said.

SPAIN, ALGERIA, AND MOROCCO.

Sponge fishing is not remunerative in Spain, Algeria, and Morocco on account of lack of good sponges. Those to be found there are mostly funnel-shaped, called elephant's ears and simply ears by the Greek fishermen. Ten sailing vessels worked in Spain in 1903 with diving apparatus, coming from Kalymnos, Syme, and Ægina; in 1904 there were only two sailing vessels from Kalymnos and none since then.

ITALY.

Official statistics of the sponge fisheries were attempted in Rome earlier than in Athens, and the Italian Naval Office has for twenty years detailed a small war vessel each summer for the supervision of sponge fishing in Italian waters. The commanders of these vessels see to the maintenance of order, give medical assistance and remedies to the diseased sponge fishermen, supply them with drinking water, and send in reports to the Naval Office. Articles based on these reports are there prepared for publication in the "Condizioni della Marina Mercantile Italiana," published each year by the Ministry of Merchant Marine, in a section devoted to the sponge fisheries. We find in these "Condizioni" abundant material on the sponge trade as carried on in Italy by natives and foreigners, and this material contains naturally some

statistical data. The majority of the foreigners are machine divers on sailing vessels flying the Greek and Ottoman flags, and the "Condizioni" report regularly cases of death, disease, and desertion among them. Since, however, the Greek divers conceal their accidents and misdeeds from the Italian authorities, the statistics are not very complete. In the summer of 1902 the Naval Office promulgated a partial prohibition of the diving machines, regulating the depth in order to prevent disease and death; but the enforcing of such partial prohibition is very difficult, and thus this measure is quite insufficient in practice, as shown by the report of the "Condizioni" for the year 1907 for the cruise of 1905, which mentions four new cases of illness of Greek sponge divers.

According to the "Condizioni" for 1906, there were in the Italian waters in the year 1904, 309 Italian fishermen on 63 sailing vessels of 1,302 tons. The total number of Italian sponge fishers for that year may, however, be computed at 1,270 men on 200 sailing vessels. The official statistics do not mention the 137 sailing vessels which departed for Tunis, nor the quantity and value of the sponges gathered by them. According to the same source, there were in the Italian waters 406 Greek fishermen on 37 sailing vessels, of which 110 on 22 sailing vessels from Kranidion were equipped with dragnet and 296 on 15 sailing vessels from Ægina carried diving apparatus. The fishing grounds were the extensive banks of Lampedusa and Pantellaria, where 36,864 kilograms of sponges, valued at 615,781 francs, were gathered as follows: For the 309 Italians, 247,184 francs; for the Greeks, 368,597 francs, or for each Italian 800 and for each Greek about 908 francs. If we consider, however, that the expenses of the fishery are far greater for the diving apparatus than for the other modes of fishing, we see that the profit of the Italians and of the minority of the Greeks without these machines was in no way smaller than that of the majority of the Greeks using the diving apparatus, with the great difference that all the Italians and the minority of the Greeks fished with harmless means, while the majority of the Greeks used apparatus injurious to their health and to the prosperity of the Italian sponge grounds. The Italian Government hoped to be able to protect these divers by its partial prohibition of 1902, but the desired results were not attained.

The Italian sponge fishers live at Terra del Greco, Porto Empedocle, Trapani, Naples, Palermo, and Catania, using mostly the dragnet and more rarely the hook, and fishing on the banks of Lampedusa, Linosa, Pantellaria, Ustica, the Æolian and Ægadian islands, along the coasts of Apulia and Calabria, Sicily, and Sardinia, and especially the coast of Tunis. In 1887 Captain Leonardo Angugliaro, from Trapani, discovered the extensive sponge banks of Lampedusa, and in the following year Greek fishermen with diving apparatus, under the Greek and Turkish flags, appeared there, to continue in Italy what they had

so thoroughly begun in their native country, i. e., the gradual but sure destruction of the sponge fishery. It was thus that the question of diving machines was introduced in Italy.

We must render the Italian Government the justice to acknowledge that it took and takes pains to obtain information. This is proved by the fact that as early as May 22, 1890, the Italian Naval Office sent a circular to the consuls at Tunis, Tripoli, Korphu, Canea, Piræus, Thessalonica, Smyrna, and Larnaka, containing questions as to the sponge fishing, but the result of this action was not published. In June of the same year the Italian Government detailed to the *Mark Antonio Colonna*, commanded by Eugenio de Gætani, Prof. Enrico Giglioli, of France, a scientist, now director of the Zoological Museum in that city. We owe to the joint work of these men several good maps of the sponge banks of Lampedusa, an unsuccessful attempt to raise sponges artificially, and a few partly correct and partly incorrect observations on the value of the diving apparatus for sponge fishing, which may be found in the report of the "Condizioni." Giglioli, a scientist of great ability, unfortunately favored the diving apparatus in this practical question, having not the least perception of the miseries it brought about. The evils of the method were thus not appreciated by the Naval Ministry and the Ministry of Agriculture, Industry and Commerce and the use of the diving apparatus was recommended to the Italian sponge fishermen often and warmly in the "Condizioni" until 1901.

These frequent official recommendations in the "Condizioni," based upon the reports of the commanders of war ships supervising the sponge fishing, and the success of the Greeks, who concealed carefully their dead and cripples from the Italians, showing only the advantages of the method, induced a few Italians in 1893 to make a few experiments with the diving apparatus. These attempts were without the desired success, however, because in order to obtain the most modest results the life and health of human beings must be sacrificed without pity and no one could or would understand this in Italy, neither the officials of the ports nor the divers who serve in the Italian navy. The experiment to obtain sponges by means of the diving apparatus was tried once and no more, as may be ascertained by the report published in 1894 in the "Condizioni." The observation of the necessary precautions for the divers being followed in Italy, sufficient pecuniary results were precluded. The Naval Office continued to recommend the use of the machines until 1901, however, though fortunately without any success, as may be seen from the reports of 1895, 1897, 1899, and elsewhere.

The following incident, mentioned in the report of the "Condizioni" of 1898 for the cruise of 1897, is very characteristic:

> The naval authorities of Lampedusa learned that several Greek divers who met with accidents during their work were secretly buried on a neighboring island. The dispatch

boat *Rapido* brought the proper authorities to the above-mentioned point, and three bodies of Greek divers were found. Microscopic examination, made by the ship's surgeon, showed that the divers were suffocated, and it was found they were afterwards buried by their comrades without notice to the authorities of Lampedusa. Thanks to the presence of the dispatch boat *Rapido*, these regrettable facts were found out and it was shown that the Greek captains of sponge vessels do not observe all the necessary precautionary measures demanded by humanity in this work.

In the interest of justice and humanity the Italian Ministry of the Navy requested the Greek Government to take measures in order that such incidents should not occur again, and the Greek Ministry published on the 3/15 of February, 1898, a circular to the harbor masters and the consular authorities, enjoining them to see that the captains of the sponge-fishing craft observed rigorously all requirements, including the circular issued by the Ministry of the Navy on April 21/24, 1896, on precautions for divers. But all these measures remained without result, because the Greek Government does not fix the responsibility for cases of death and sickness, as we have already mentioned. The Ottoman Government likewise holds no one responsible for the abuse of the diving apparatus in spite of the prohibition of August, 1902.

Fortunately a change has taken place since 1901 in the attitude of the Italian Ministry of the Navy in regard to the diving apparatus. In addition to the partial prohibition of 1902 in regard to the depth, we find in the "Condizioni" during the later years reports almost similar to that of 1906 for the cruise of 1904, which I transcribe here:

> The use of diving apparatus, which was fortunately not adopted by our sponge fishermen, is, although preferred for the selection of the product, always harmful and often deadly to those using it.

This sentence and especially the word "fortunately," as well as the partial prohibition of 1902, is a declaration of the Ministry of the Navy of conviction that the diving apparatus is harmful, a conviction which ought to be substantiated by an entire prohibition. The limited questionable merit for selection of the product is of very small practical value and is easily changed into an evil if we think that after the selection of the large sponges soon the smaller and smallest are taken and the young growth is being crushed by the heavy and broad soles of the divers. The use of diving apparatus in sponge fishing is thus wholly condemned and ought to be prohibited by every wise government.

The other official body in Rome concerned with the fisheries, the Commissione Consultiva per la Pesca, which has been for more than twenty years a part of the Ministry of Agriculture, has as yet taken no action further than to recognize the question as deserving of study, action being deferred pending fuller information. Such delay is most dangerous to the interests at stake, since much evil may be done during the time consumed in further study of the subject.

AUSTRIA-HUNGARY.

The sponge fisheries in Austria-Hungary are located in the village of Crappano, district of Sebenico, in Dalmatia. There were, in 1904, 140 sponge fishermen on 70 barks. Each bark carries a rower and a fisherman, with a five-pronged hook which has a handle 18 meters long. The men smooth the surface of the sea by pouring oil over it, instead of using the tin cylinder with the glass bottom. The annual harvest of sponges per man varies from 225 to 500 crowns in value; a few earned 800 crowns in 1897. The two former figures are below and the latter is above the sum mentioned by the "Condizioni" for the Italian sponge fishers in 1904, i. e., 800 francs.

The Oesterreichische Gesellschaft für Seefischerei und Fischzucht, in Trieste, from whose reports I have taken the data for sponge fishing in Austria-Hungary, have recommended the diving machine to the sponge fishermen of Crappano since 1892, the Imperial and Royal authorities of Trieste prescribing that on the coast of Istria and in the vicinity of the islands of Quarnero the apparatus should not be used at a depth of less than 12 meters and in the Dalmatian waters at a depth of 20 meters; but the enforcement of this requirement is very difficult. Experiments with the diving apparatus failed, however, as in all cases in which an enlightened government provided for personal safety of the divers and the future of the sponge beds. Observation of the necessary precautions precluded all profit. These efforts were met likewise with an obstinate resistance on the part of the majority of the sponge fishermen of Crappano, who recognized a great danger in the diving apparatus. Their own experience as well as the resolutions of the International Fishery Congress at St. Petersburg in 1902, at which the Oesterreichische Gesellschaft was represented, caused the latter to desist from further encouragement of the diving apparatus.

The same society resolved in 1904 to make experiments with the dragnet at depths over 40 meters, having in mind the considerable results obtained by this mode of fishing in the waters of Lampedusa. Such an apparatus was made for the society by a Greek sponge fisherman in Trieste. I have not yet, however, obtained a report of the results it yielded. The Austro-Hungarian waters are divided into zones for sponge fishing, in order to allow time for the sponges to grow to their full size and propagate, and it is forbidden to take sponges of less than 6 centimeters in diameter.

UNITED STATES.

There are numerous sponge banks in the waters of the Gulf of Mexico, especially south and west of Florida, Cuba, Haiti, the Bahama Islands, which are situated outside the Gulf, and in other places. Sponge fishing in the state of Florida has its centers at Key West, Tarpon Springs, and Apalachicola. In 1900

this industry was followed in the first locality by 1,827 persons, in the second by 354 persons, and in the third by 64, making a total of 2,245. Among these, 1,239 men were working on small vessels, 874 on barks, and 132 on shore. There were 1,356 colored and 75 white men among the sponge fishermen, and among the workmen on shore there were 119 white and 13 colored men. According to nationalities, 1,268 were British subjects, mostly from the Bahama Islands, of which 1,013 were colored; 839 were citizens of the United States, of which 343 were colored, 5 Portuguese, and 1 Norwegian. Among the men working on shore 114 were citizens of the United States, all white, and 1 Greek. Up to 1905 the sponges were gathered in Florida exclusively by means of the hook. It is to be regretted that the dragnet is prohibited for the greater depths where the hook can not reach.

In 1900 there were used in sponge fishing 156 small vessels of 1,750 tons in all, valued at $182,151, and 228 barks valued at $176,465. The trade in native sponges was concentrated at Key West and Tarpon Springs, and was carried on by representatives of firms in New York, Philadelphia, and St. Louis, with the exception of one independent firm in each of the two above-named Florida localities. These firms had in this year 17 buyers and 124 other employees and workmen, the annual salary of whom amounted to a total of $43,947. In 1900 there were obtained in Florida 418,125 pounds of sponges, valued at $567,685, while in 1880 there were gathered 207,000 pounds of sponges, valued at $200,750. (These data are taken from official reports of the United States Bureau of Fisheries.)

In February, 1905, the question of sponge diving arose in America. In the course of a few months 70 diving machines from Greece and Turkey, increasing to 100 in the following year, appeared in Florida, and, so far as I could ascertain at such a distance, operated without loss of life, since the work was done in shallow waters. It did so much the more harm to the future of the sponge beds, however, and the practical Americans did not need much time, fortunately, to see the danger threatening from these reckless foreigners. Thus the question arose in the United States, and those concerned were divided into two large groups with diverging interests for and against the diving apparatus, exactly as previously in other countries. All who could obtain a temporary profit declared themselves in favor of the diving apparatus, while all those who had regard for the future were opposed. Both parties had influence and sought justice and protection from the Government, and the matter came before the Houses of Congress in Washington, there to be very promptly investigated and acted upon.

On June 20, 1908, was passed the beneficent law by which the diving dress in sponge fishing was absolutely prohibited in depths of 50 feet and less, and

at depths greater than 50 feet it could be used only from October 1 to May 1. Moreover, the taking of the sponges of a diameter less than 4 inches was prohibited, under penalty of a fine of $100 to $500 or confiscation of the vessel and the diving dress. The important action of the Government of the United States was undoubtedly influenced by the resolutions of the International Fishery Congresses held in St. Petersburg in 1902 and in Vienna in 1905, as well as by the beneficent legislation of so many countries of the Mediterranean Sea, for these were frequently mentioned in the debates upon the subject, as were also the reports of American consuls in countries of this vast sea basin, who have given and still give this important question the consideration it merits, as may be seen from the report of Consul G. B. Ravndal in Beirut. The practical spirit of quick resolution in the Americans deserves high commendation and imitation, and it is to be hoped that this recent excellent example of forethought will influence the slower governments to early action in this important matter.

RÉSUMÉ.

Most of the sponge-bearing countries—Samos, Crete, Egypt, Tunis, and Turkey—exact only a moderate payment of dues from each vessel. Cyprus did the same until 1904; since that date the government of this island has exacted a very high percentage of the harvest of sponges, which is unjust and, moreover, unpractical, as it demands the continuous supervision of each sponge-fishing vessel. The United States, Austria-Hungary, Italy, and Greece exact no fees. I lack the necessary information in this regard as to Cuba and the Bahama Islands.

In fact, as I have stated, there is a lack of complete and general statistics on sponge fishing, especially as to injuries to health and life of the sponge fishermen and the condition of sponge beds arising from the use of the diving apparatus. I obtained the following approximate figures, which vary, however, from year to year, by long years of observations and investigations. The number of diving machines in use by part of the sponge fishermen of Hydra and exclusively by those of Spetzæ and Ægina in Greece; by part of the sponge fishermen of Kalymnos, Syme, Chalke, and Kastelloriso, and exclusively by those of Aivali, Moschonisia, and Marmora in Turkey, has varied according to the year from a few in 1866 to 225 with 1,200 divers and 1,500 sailors in 1898. The adherents of the three good methods may be computed at 10,000 in round numbers, fishermen and sailors, from Syria to Florida. Yet even this figure varies, though somewhat less, according to the years. With their families and the families of the classes closely united with them as priests, teachers, merchants, and artisans, the sponge fishermen form a population of more than 100,000 heads. The yearly mortality of sponge fishermen in the diving apparatus is

about 20 per cent and the seriously and slightly diseased reach annually 25 per cent. The health of the sponge fishermen working with the hook and the dragnet is not exposed to the slightest injury. Only the naked divers run at times the danger of being attacked by a shark, but accidents of this kind are so rare that the fishermen do not consider them at all. The number of victims of the diving apparatus during the entire time of the abuse, i. e., during forty-two years, may be computed at 5,300 dead and 2,300 seriously disabled, while cases of slight diseases, transformed into serious ones with time and ending in death or chronic ailment, attack all divers after a longer or shorter period of work in the machines.

For the future of the fishery as well as the welfare of the fisherman the diving machine is most harmful. It has been contended that the diver fishes without disturbing the bottom. This is not true. The heavy apparatus breaks and crunches the embryo sponges that lie in the path of the diver, and he searches over the entire sponge-bearing area. He takes, moreover, not only the largest and best sponges but also the small ones, arguing that what he does not take to-day will be taken by some one else to-morrow, and he fears also the cruel captain. The naked divers, on the other hand, are unable to take so many sponges or to harvest so closely, since their stay under water must be brief. Their season is from April to September. The hookers and the dragnet fishermen work throughout the year, but it is to be noted that the dragnet can not be used either in total calm or in gale or storm, while calm or light breezes are necessary for the naked diver or the hooker. Thus it will be seen that each of these methods is subject to frequent and sometimes long-continued interruption. Their harmlessness as compared with the scaphander is obvious.

Experiments in artificial raising of sponges, although undertaken frequently, have never been successful and probably never will be on account of the very nature of things. When the sponges are torn from their roots a milky fluid flows from their elastic tissues, and it is this fluid that contains the germs of new sponges, which are carried along by the currents as the seeds of some plants are carried by the wind, until they attach themselves and grow. A sponge needs four to five years to reach maturity, after which it begins to die, having discharged its fluid with the germs. The sea currents, which the sponge needs for its growth, are an obstacle to artificial raising of sponges, for while they allow the microscopic embryo to fasten itself to a suitable spot, they do not permit cuttings selected for culture purposes to do so, and the equipment necessary to overcome this is easily destroyed by storms. Moreover, if it were possible for science to succeed in effecting this miracle, on a small scale and at a large expense, the result would be of no commercial value, as all the most effective conservation of the sponge beds would be accomplished by prohibition

of the diving apparatus. This would cost neither money nor labor, and under it the sponges would propagate abundantly, while hundreds of lives would be saved or benefited thereby.

APPEAL TO THE INTERNATIONAL FISHERY CONGRESS.

My work in the cause of the sponge divers at first consisted of efforts to arouse public interest in their behalf, by written communications and petitions, by publications in the press, and by lectures on the subject. I at length, however, resorted to direct appeal to the authorities of the different countries concerned, presenting my cause in person. I have likewise organized societies or enlisted the efforts of existing organizations wherever possible, and have brought the matter before various official and unofficial bodies. As recounted in the preceding pages, all of the sponge-bearing countries of the Mediterranean, and also the United States of America, have passed prohibitory or restrictive laws. For the most part, however, the laws have been ineffective, by reason of intrigues on the part of advocates of the scaphander and indifference on the part of the governments. The various international congresses before whom the question has been brought, while in one or two instances slow to act, have for the most part given prompt and full indorsement of my plea. I am now addressing the International Life-Saving Congress at Frankfort on the Main, and at the same time making a fervent appeal to the International Fishery Congress at Washington. The measures for which I solicit the support of these congresses are the following:

(1) Prohibition of the diving apparatus and protection of the three good modes of fishing brought down from antiquity.

(2) Inauguration of an international supervision of the execution of international measures against the illegal sponge fishing with diving apparatus in neutral waters where the national supervision is not sufficient.

(3) Establishment of life and accident insurance as well as of savings banks for the sponge fishermen.

(4) Care of the surviving victims of the diving apparatus.

(5) Levying of dues for the permission to take sponges, and the utilization of part of this revenue in behalf of the sponge fishermen.

(6) Rigid supervision of the execution of these measures on land and on water.

Since parts of this programme have already become law in various interested countries and have operated with the best of success, there is reason to hope that they will soon meet with recognition and execution in countries where little has as yet been done for the suffering sponge fishermen.

The question of maritime jurisdiction is a further problem of importance in the sponge fisheries. Greece, Turkey, Tunis, the United States, and lately

Egypt, have accepted the 3-mile limit in the dispute as to the use of the scaphander—an old formula not applicable in scientific administration of the sponge fisheries, since the sponge grounds often lie beyond that distance from the coast. It is to be hoped that all enlightened governments will give due recognition to this fact and in regard to the sponge fishermen will assume jurisdiction over a zone of 60 miles to seaward, abolishing the abuse of the scaphander within that territory. I earnestly solicit the International Fishery Congress to recommend such action.

A PRACTICAL METHOD OF SPONGE CULTURE

By H. F. Moore

Scientific Assistant, United States Bureau of Fisheries

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of $100 in gold offered by Hayes Bigelow for the best demonstration, based on original investigations and experiments, of the commercial possibilities of growing sponges from eggs or cuttings

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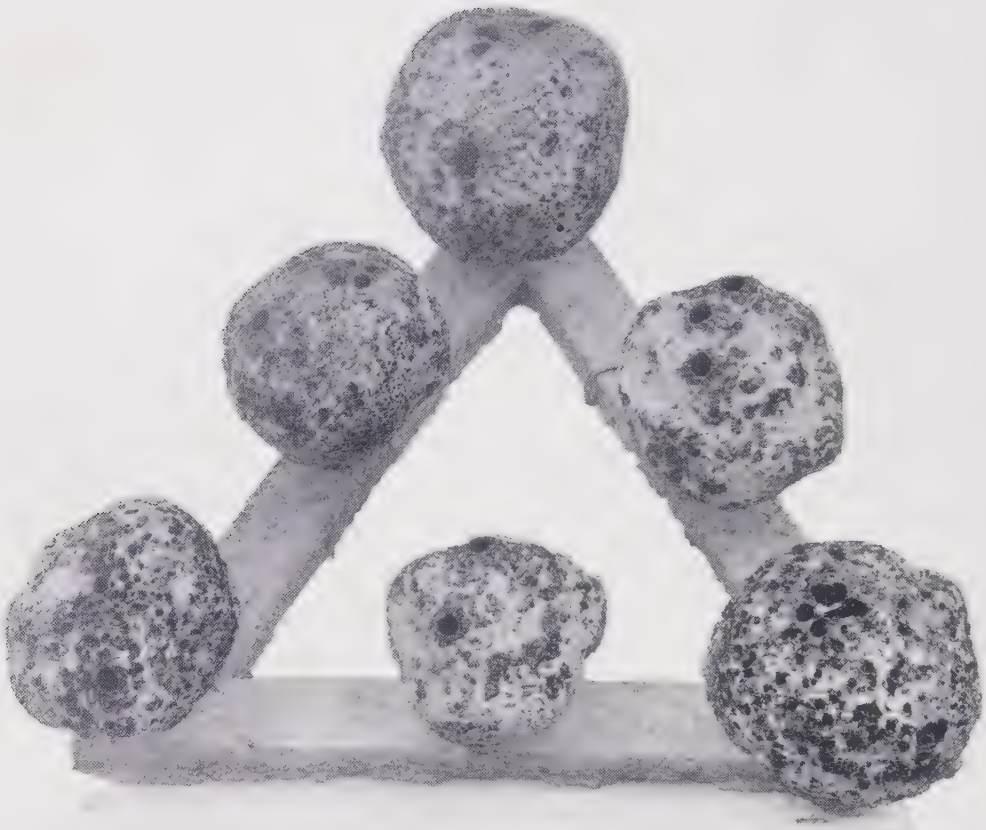

Fig. 1.

Fig. 2.

SPONGES GROWING ON CEMENT TRIANGLES USED IN EXPERIMENTAL PLANTS OF CUTTINGS.

A PRACTICAL METHOD OF SPONGE CULTURE.

By H. F. MOORE,
Scientific Assistant, United States Bureau of Fisheries.

CONDITIONS AND NEEDS OF THE SPONGE FISHERIES.

As has been shown elsewhere,[a] all or most of the important sponge beds of the world are being fished in such manner as to give more or less grave concern as to their depletion. In the Mediterranean, the Bahamas, Cuba, and Florida the danger of commercial extinction is exciting discussion among the thoughtful, though often denied by the more shortsighted of those who are most intimately concerned, the persons who as fishermen and dealers are dependent upon the sponge fishery for a livelihood. The reasons for the imminence of this danger the writer has elsewhere discussed and the condition is here taken for granted.

Statesmen, men of science, and men of affairs have all taken part in the discussion of the measures necessary to perpetuate the supply of this commercially valuable and almost essential product, viewing the situation not only from the standpoint of the sponge fisherman and the dealer, but from the more important view of the consumer, who can find no satisfactory substitute for the sponge in many of its applications to the arts and domestic uses. It is indubitable that the threatened extinction of many of the beds is due to the employment of methods of fishing which are in themselves destructive, and that, especially in Florida, the Bahamas, and Cuba, a still greater danger lies in the improper use of methods which, properly controlled, would be open to no reasonable objection.

The illegitimate taking of small sponges on the Florida coast by both divers and hookers is, for instance, an almost wanton destruction of natural wealth. Many of these small sponges, of little practical use and worth but a few cents apiece, if given two years' additional growth would increase in value a score, and in addition would furnish myriads of larval sponges to replenish the bottoms bared by more legitimate operations. Every young sponge has

[a] Moore, H. F.: Commercial sponges and the sponge fisheries, Bulletin Bureau of Fisheries, vol. XXVIII, 1908, p. 399–511.

commercial potentiality both as an individual and as a parent, and in both respects its utility is vastly curtailed by premature destruction.

Legal measures for the prohibition of especially destructive methods, and the regulation of abuses connected with the more legitimate means of taking sponges, would undoubtedly, if properly enforced, do much to make more remote the depletion of the beds. But aside from the difficulties encountered in enforcing such legislation, as is witnessed in the failure of the considerable navies maintained by some of the states to enforce the oyster laws, such regulation could but retard the approach and not prevent the arrival of the day when the product of the natural beds will be inadequate to the demands of the markets. Even a legitimate fishery prosecuted under the spur of an increasing demand is eventually able to exterminate for all practical commercial purposes any sedentary organism toward which it may be directed.

When the demand is light and prices consequently low, as they were for many years after the discovery of the Florida beds, the more populous grounds only may be worked with profit. When the sponges become so few and scattered that the time spent in looking for them greatly exceeds that expended in actually taking them from the bottom, profits are reduced to a degree when a closed season is automatically established by the removal of the spongers to other and denser grounds, and an opportunity is given for the replenishment of the beds by natural means. As the demand increases and the product becomes more valuable, more persons are attracted to the fishery, the methods become more efficient, and the degree of depletion of the beds, serving as a deterrent to further operations, more nearly approaches the limit of actual extinction. The beds are scoured year after year for the few remaining sponges, the decreasing supply and the increasing demand operating together to make profitable a closeness of search before unthought of and giving a value to small and otherwise undesirable sponges which in the earlier days of the fishery would have been allowed to lie unmolested on the bottom for want of a market. The consequence of this is that when a ground is finally even partially abandoned as a profitable fishery so few sponges are left, and these are so small in average size, that the reproductive capacity of the area is most seriously reduced and a long time must elapse before the bottom can be reseeded by nature's unaided operations.

Some assistance could be rendered by the establishment of closed seasons, not so much those which prohibit fishing for a more or less restricted period each year, but such as would deny the right to fish on given depleted areas for terms of sufficient duration to permit the remaining young sponges to grow to reasonable marketable size and become of greater potential value in reseeding the area with a fresh crop of young. If such regulation could be rigorously and intelligently enforced, and if it were supplemented by measures preventing the taking

of sponges of a less diameter than at least 4½ or preferably 5 inches, the danger of extinction of our American beds would be eliminated; but there are certain serious objections which may be urged against this solution of the difficulty, which at best can be but a partial solution. Aside from the difficulties and expense of enforcing such regulations and the hardship which they may at times work upon the spongers, the most serious objection is that they would from their very nature restrict the output of the fishery, or, at best, would not permit its development commensurately with the increasing demands of the markets. The writer has discussed the question at length in the paper above referred to, but for present purposes it appears to be advisable briefly to consider again the force of the last and major objection just mentioned, particularly with reference to the waters of the United States, although the application is general.

That the demand for sponges is growing rapidly can not admit of dispute. Prior to the discovery of the beds of Florida the imports of sponges into the United States were insignificant, and of course none was produced at home. There was practically no demand, except for domestic purposes. Thirty years later, in 1879, the imports had increased to an average value of $100,000 to $120,000, while the average annual importation for the three years from 1905 to 1907 was valued at no less than $531,745. The domestic production grew from nothing in 1849 to $200,000 in 1880 and an average of $658,403 per year from 1906 to 1908, most of which was consumed at home. In certain other countries also, notably Russia, Turkey, Spain, and the various states of South America, where very few or no sponges were formerly used, the past two decades have developed an important consumption. With the development of civilization and modern methods of industry the countries of Asia, too, are sure to make important demands for this practically indispensable product of the seas.

No doubt new beds will be discovered from time to time and new regions will come into productiveness, but it is not believed possible, in view of what is known of the resources of the sea in most localities in which sponges may be expected to occur, that any vast areas producing the more desirable grades will be brought to light. If regulations governing the fisheries will merely preserve what we now have and will not materially augment production, there is forced upon us consideration of the necessity and possibility of increasing the supply by artificial means analogous to those employed in oyster culture or some other type of aquiculture. From a study of the breeding and life history of the commercial sponges two broad avenues of experiment open themselves. Research has shown that sponges may be propagated either in the natural sexual way by means of eggs, or artificially by cuttings or their equivalent. The following is a brief history of various observations, experiments, and suggestions in these directions:

PREVIOUS EXPERIMENTS IN SPONGE CULTURE.

The basis of sponge culture by means of cuttings is in an observation made by F. Cavolini[a] in 1785, that sponges cut into pieces would attach to foreign bodies and grow.

In 1862 Oscar Schmidt[b] repeated and confirmed this observation and was apparently the first to make the practical suggestion that the regenerative phenomena might be utilized in the development of a system of sponge culture. This suggestion bore fruit in the following year when the Austrian Government and certain merchants of Trieste established a station on the island of Lesina, which in 1867 was placed in charge of Gregor Buccich. Of the experiences of the first four years of this work there appears to be no record, but Buccich submitted a report which was made the basis of a paper by Dr. Emil von Marenzeller[c] in 1878.

Buccich appears to have discovered most of the salient facts relating to the growth of sponges from cuttings. He found that sponges can be removed from the water and cut in the air without injury; that in cool, damp weather they can be exposed to the air for eight hours without suffering material injury; that they can be cut and handled with less liability to injury during the winter; and that the cut surfaces will grow together or to certain foreign bodies with which they may be placed in contact. He observed also that apparently similar cuttings were sometimes dissimilar in their rates of growth, and that some cuttings would heal and live for years without material increase in size. Concerning the rate of growth, the information is indefinite. The cuttings were small (about 1(?) inch cube) and they are stated to have doubled or trebled in size (bulk?) during the first year, and to have grown to a "considerable size" in five years, but that seven years would be required to produce a commercial product. There is no statement of the actual mortality among the cuttings experimented with, but it is estimated, upon what basis does not appear, that it would not be over 10 per cent during the seven years.

The methods employed by Buccich were various. He pegged the cuttings to stones, to the inside of wooden boxes, and to various other contrivances. In perforating the cuttings to admit the pegs, which latterly were of bamboo, he used "a trepan 6 millimeters wide, fastened to a vertical turning table, which was kept in rapid motion by a fly wheel." The experiments were ultimately abandoned after nine years, mainly on account of the hostile attitude of the inhabitants. The somewhat elaborate methods of handling and planting

[a] Cavolini, F.: Memorie per servire alla storia de' polipi marini. Naples, 1785.

[b] Schmidt, O.: Die Spongien des Adriatischen Meeres. Leipzig, 1862.

[c] Von Marenzeller, E.: Die Aufzucht des Badeschwammes aus Theilstücken. Vienna, 1878. Translated in Report U. S. Fish Commission, 1879, p. 771–777.

the sponge and the character of the materials employed appear to have been unfit for commercial application. Marenzeller observes: "As far as our present knowledge goes, it is certain that sponge culture will not be profitable for poor men, but can be only carried on successfully on a very large scale either by wealthy individuals or by joint stock companies."

The failure of Buccich's work to yield commercial results appears to have ended experiments in Europe, but about 1879 Mr. Fogarty, a sponge buyer of Key West, Fla., planted 216 cuttings in a depth of about 2½ feet of water. The pieces were about 2½ inches long; they were attached to the bottom by sticks and wires, and it is stated that it required four months to repair the injuries and reestablish growth. Four specimens, said to be six months old, sent to the National Museum are stated to have grown from four to six times the bulk of the original cuttings. This experiment was never pushed to a conclusion, and the fate of the cuttings, other than those mentioned, is unknown. A few years later Mr. R. M. Munroe, of Cocoanut Grove, Fla., began work in Biscayne Bay, where for several years he experimented in fastening cuttings to stones and various arrangements of stakes forming hurdles and frames. A large proportion of the pieces survived and grew to some extent, but none reached a greater bulk than 3 or 4 cubic inches, and practically all were eventually destroyed or lost. The bottom selected and the materials employed were in some cases unsuitable and in others the antagonism of some of the spongers prompted them to destroy the plants. At this time the first sponge-culture law was presented to the legislature of Florida, but it was subsequently so amended as to be highly objectionable and unjust to the spongers and it consequently failed of passage.

About 1897–98 several thousand cuttings were planted at Sugar Loaf Key by Dr. J. V. Harris, of Key West. They were attached to galvanized iron wire laid on the bottom, but the wire soon corroded and broke into short pieces, the sponges became detached, and the mortality was very high. From time to time I have picked up a considerable quantity of this wire with a few attached sponges. Growth appears to have been slow or, after a while, almost entirely arrested, and the largest specimens seen by me have been under 4 inches in diameter at an age of from 3 to 5 years, the exact age of any given specimen being indeterminate. The quality of the sponges in the vicinity of their attachment was also injured by iron rust. In addition to the sponges planted as described, Doctor Harris planted many thousand cuttings by sowing them broadcast over the bottom. It is not improbable that some of these may have attached to rocky patches of bottom and grown, but if so they became indistinguishable from the natural growth, and their history is lost.

In January, 1898, Dr. H. V. Wilson presented before the National Fisheries Congress, held at Tampa, Fla., a paper[a] making some suggestions on rearing sponges from the egg and on improving their quality by grafting. In June, 1907, he published[b] some results of his experiments with certain noncommercial sponges at the United States Fisheries Laboratory, Beaufort, N. C., demonstrating that they could be raised by regeneration from degenerate masses to which the sponge is reduced under certain artificial conditions of confinement. Doctor Wilson suggested that this phenomenon would probably be presented by the sponges of commerce and might be utilized in a system of sponge culture for economic purposes. The same investigator has since discovered that practically the same effect can be produced by squeezing the soft parts of the sponge through bolting cloth into vessels of sea water, the expressed tissue substances, aggregating themselves into little heaps on the bottom, eventually regenerating the skeletal tissues and developing into complete sponges. None of these experiments has been performed on commercial species and the growth of the new individuals has not been kept long under observation, but I believe that there is no good reason to doubt that it would be possible to apply the methods successfully to any of the economic sponges of Florida.

With the exception of my own investigations and the related and parallel experiments of Messrs. Cheyney and Bigelow recounted in the main part of this paper, I believe the foregoing to cover all actual experiments in sponge culture, save one or two cases in which a very few cuttings or small sponges have been planted on the bottom by persons engaged in the industry; but in 1895 Bidder[c] considered the question from a purely academic standpoint and raised certain questions as to the utility of the whole project. Mr. Bidder on a priori grounds reached the provisional conclusions, inter alia (1) that the total volume of the new sponges grown from cuttings would not exceed the volume of the original sponge if it were permitted to attain its natural growth under the same conditions for an equal time; (2) that sponges or cuttings raised above the bottom, as in Buccich's experiments, would probably grow more rapidly than the same or similar individuals on the bottom; and (3) that the sponge-bearing area, naturally confined practically to the bottom, might be extended by using a suspension system of culture in which several strata between the surface and the bottom might be utilized by appropriately constructed supports for the growing sponges. How far some of these questions are answered by my own experience will be seen in the following pages.

[a] Wilson, H. V.: On the feasibility of raising sponges from the egg. Bulletin U. S. Fish Commission, vol. xvii, 1897, p. 241–245. 1898.

[b] Wilson, H. V.: A new method by which sponges may be artificially reared. Science, n. s., vol. xxv, no. 649, p. 912–915. 1907.

[c] Bidder, George: Notes on projects for the improvement of sponge fisheries. Journal of the Marine Biological Association of the United Kingdom, vol. iv n. s.) p. 195–202.

POSSIBLE LINES OF EXPERIMENT.

Under instructions from the Commissioner of Fish and Fisheries, experiments in sponge culture were inaugurated in January, 1901, at Sugar Loaf Key and at divers places in Biscayne Bay. From the beginning the aim has been not to demonstrate purely scientific possibilities, but to develop, if possible, a system of sponge culture having present economic application, the condition of the fishery being such that there may arise at any time an exigency demanding immediate measures of relief to the overtaxed natural beds.

As has been seen from the preceding historical résumé, a number of theoretical considerations have been offered by various persons and several attempts have been made toward a solution of the problem. It has been proposed to multiply and improve sponges by growing them from cuttings, from the egg, and from the peculiar degenerative masses described by Wilson, and by grafting superior varieties upon those less desirable. Each of these, except the third, which has been but recently discovered, was considered when the present experiments were begun.

GRAFTING.

It does not appear that there is much of value in the suggestion as to grafting, which is based upon an imperfect analogy between certain aspects of the process of growth in sponges and in the higher plants. Cut surfaces of related varieties of sponges, as of related varieties of plants, will fuse and heal if brought into proper apposition, but there the analogy ends. In grafted plants each member of the union (stock and scion) furnishes essential parts of the compound, the stock supplying the roots and trunk of a tree, while the scion develops the branches, foliage, and fruit. Without foliage the stock would die, and without roots the scion would not survive. In plants, too, each member of the graft produces a definite influence on the resultant whole, making it more or less unlike either of the pure varieties of which it is compounded. The fruit produced on the scion will differ from that which is produced by the ungrafted stock, while the influence of the latter may be seen in greater hardiness, a different size and general habit, or in other respects. With sponges the case is quite different. The two members of the union will have the same organs and be essentially similar even though they may differ in quality and texture. One piece may be attached or rooted, but that is immaterial and in a measure accidental, for the so-called root is merely a part of the surface adherent to some foreign body and performs no particular function other than that of anchorage. If the sponge be torn loose, some other part of the surface may with equal facility become the root, or more likely the sponge will continue to live and grow as an unattached individual or "roller." As has been shown by experiment, if a graft be made, each piece will continue to grow independently without influence upon its fellow except in limiting

the direction of its growth, although the character of one or both may be affected by any change in environment. A cutting from a sponge transplanted and grafted on another growing in a different environment will tend to approach the latter in character, not as the result of the graft, but on account of the physical surroundings, precisely as it will do if transplanted to the same locality without grafting. In other words, nothing can be done by grafting that can not be more readily done by propagation from cuttings which attach themselves, and the former process results in a waste of time and effort without compensating advantages. Neither cutting is improved by the amalgamation. Sponges of the same species will unite if grafted. Sheepswool sponges from different localities readily fuse, but they will not unite to either yellow or grass sponges, and probably not to any species other than their own.

GROWING FROM EGGS.

That sponges can be grown from eggs to a marketable size under the control which is essential to any system of sponge culture appears probable, but it has not yet been demonstrated. Although experiments made with the noncommercial sponges show that they can be kept alive for a considerable time after development from the egg, I know of no cases in which they have been artificially raised to maturity or to any considerable size, and experiments with the commercial sponges are still less conclusive. Raising sponges from the egg must probably always remain a delicate operation, practicable only to skilled investigators provided with special facilities and entirely beyond the reach of the practical man engaged in a commercial enterprise. For that reason the method appeared to be ill-adapted to the present needs of the sponge fishery and was therefore discarded in the experimental work described in the present paper. As has been pointed out, however, in an academic discussion of the proposition by H. V. Wilson, it may be that this method will have a distinct place in the sponge culture of the future, though its development and practice must probably necessarily be in the hands of a few skilled operators. It may be possible to breed sponges from selected parents, thus improving their quality and supplying better seed sponges from which to make cuttings. Possibly some system of hybridization may be developed along lines analogous to those which have produced such astounding results in the hands of experimental horticulturists.

The plasticity of sponges and their extreme susceptibility to environmental influence, as well as the technical difficulties which the experimenter must overcome in his attempts at breeding and hybridization, will probably long postpone, if they do not entirely defeat, successful efforts in this direction. The problem is one which may well be taken up and studied when the Bureau of Fisheries comes into possession of a properly equipped laboratory in the sponge region of Florida.

GROWING FROM DEGENERATIVE BODIES AND TEASED OR DISSOCIATED TISSUES.

Wilson's extremely interesting and scientifically important studies in this field open, as he points out, a new means by which sponges may be propagated. The experiments so far have been confined to noncommercial species, but there appears to be no reason for believing that they can not be applied to horny sponges. In fact, in certain "sick" sheepswool sponges in my experimental plants I have observed in the dead skeletal remains certain degenerative masses resembling, at least superficially, those described by Wilson in silicious sponges.

Wilson's methods are to induce the partial death of the sponge and the production of small degenerate bodies in the remaining living tissue, or to tease up the soft tissue, or finely divide it by squeezing it through bolting cloth bags. The resulting small masses speedily attach and regenerate into little sponges.

Leaving out of consideration the morphological significance of these processes, and viewing them solely from the practical standpoint of sponge culture, these methods of rearing sponges appear to be essentially similar to rearing from cuttings made with a knife, the main difference being that the tissue aggregates, or pieces, are obtained by an elaborate method instead of a simple one.

GROWING FROM CUTTINGS.

This method was adopted as that giving greatest promise of success, and it is discussed in detail in the following chapters.

PROPAGATION OF SPONGES FROM CUTTINGS.

Growing sponges from cuttings has to recommend it, as a practical method, its simplicity and the certainty with which the excised pieces will attach and regenerate when placed under suitable conditions. The ease with which suitable seed sponges may be obtained at any season, their immunity from the effects of more or less rough handling, the facility and rapidity with which they can be attached to such materials as may be selected, the promptness with which they will grow fast to suitable foreign bodies, and the certainty with which they heal and grow into perfect sponges make this an immediately feasible method of sponge culture, provided the proper means of attachment and methods of handling can be developed. How far the present experiments have solved the problems will be seen in the following account.

SEED SPONGES.

For seed any healthy sponge may be used, whatever its shape or size. Torn and irregular specimens, or those so filled with sand and other foreign matter as to make them of little value in the markets, may be utilized equally with well-shaped ones, though they often do not cut so economically in respect to either material or time. When the seed sponge is heavily loaded with shells, corals,

and similar material, there is always considerable waste and much time is lost through the dulling of knives and the necessity of avoiding obstacles too stout to cut. For this reason it is economy to select the cleaner specimens for seed when they can be readily obtained. The sponges as fast as detached from the bottom should be placed in a gunny sack or net attached to the side of the boat or, if taken by diving, carried by the diver, the sack when full being emptied into a live car. During cool or moderately warm weather, treated thus, they will remain alive and uninjured for several weeks, though if the sea be rough their surfaces are likely to become more or less abraded by rubbing against the sides of the car. They must not be brought into water at all brackish, however, or they will be speedily killed. In warm weather if long confined even in salt water some will sicken and die, and the resulting foul water will soon produce a general epidemic.

In carrying live sponges from the beds to the planting grounds a boat-shaped or spindle-shaped live car will be found most convenient, as either can be towed rapidly and for long distances without injuring the contents. The car should be provided with several "thwart-ship" bulkheads or partitions dividing it into compartments, and the slits or perforations in the forward end should be small or narrow so as to reduce the violence of the currents set up by its rapid passage through the water. If these openings be large, the sponges will churn violently or be massed under pressure at the after ends of the compartments and are certain to be more or less injured. The car preferably should be constructed entirely of wooden slats and boards, as wire netting tends to abrade and injure the surfaces of the sponges. Where a boat with a small "well" is available, sponges can be transported in that, or when the distance is short they may be carried in tubs of water protected from the sun by cloths or sacks, but they should be removed from the tubs and placed in open water as soon as opportunity occurs. In cool weather they can be readily carried for many hours without water if they are protected from the sun and rain and kept moist with sea water. At the planting grounds the sponges may be kept best and most conveniently by stringing them on rope yarns about 5 or 6 feet long, the two ends of which are then tied to stout lines or wires stretched between stakes so that the sponges are suspended just clear of the bottom. In a situation where the water is sufficiently salt and pure they will readily live longer than the lines will last, and at the same time they will be easily accessible, those required from time to time being conveniently detached without disturbing the remainder.

There is some reason to believe, as is discussed later, that in regions which have been for years subject to an intense fishery, especially where the water is shallow and generally clear, a race of slow-growing small sponges may be developed by constantly selecting out the larger more rapidly growing specimens,

and that cuttings made from such seed will not grow as rapidly as those from more virile stock. When there is reason to suspect this, seed should be brought from other localities.

CUTTINGS.

In the beginning of the present experiments the cuttings used were small, about 1 by 1 by 1½ inches, the purpose being to secure as many plants as possible from a given quantity of seed sponges. This size gives from 100 to 120 plants from a 6-inch sponge. Theoretically the use of small cuttings was correct for securing the greatest ultimate product from a given amount of material. As is shown hereafter, the average growth in diameter is fairly constant for the first four years at least, and the relative increase in volume or weight is therefore greatest when the cuttings are small. Growing at the average rate of 1 inch per year, 120 cuttings made from a 6-inch sponge would in four years reach a volume of about 75 times that of the original sponge, provided there was no mortality, whereas the same sponge cut into 20 pieces, in the same time and under the same conditions, would increase about 20 times, while if the seed sponge were planted entire it would increase but 4 or 5 times, provided it grew at the average rate established for specimens up to 8 inches in diameter. This is illustrated in principle, though not in detail, in figure 6, page 575. The solid line shows graphically the growth of an entire sponge, the middle dotted line the aggregate increase in a sponge of the same size cut into 20 pieces and the upper line the increase when cut into 50 pieces, in each of the latter two allowance being made for a mortality of 5 per cent of the cuttings per annum.

It was found, however, that the smaller pieces were placed at considerable disadvantage by reason of the greater readjustments required to perfect again the canal system, and moreover when they were injured, as frequently happens, a proportionately larger part of their substance was affected and the regeneration required to convert the fragments into functionally and anatomically perfect sponges was more drastic. These two factors operated to produce a somewhat higher mortality in the small cuttings than in larger ones, and moreover tended to retard materially the growth of the first six months, though after that there was little difference between the diametric increase of large and small pieces. The smaller cuttings also require a longer time to reach a marketable size, the planter has to wait longer for his returns, and in the meantime the sponges are subject to such risk of disaster as may exist. In properly selected localities the last consideration is not very grave. It was necessary, therefore, to effect a compromise between the theoretically economic advantage of employing small cuttings and the practical biological superiority of large ones, and it was finally established that pieces about 1½ by 2½ by 3 inches

(pl. LXIX) or of approximately the same volume, were the best, all things considered. The shape of the cuttings will, of course, vary with the size and shape of the seed sponge, but the more nearly equilateral they can be made, the more generally satisfactory they will prove. Thin edges or ragged parts are likely to die and slough off.

In making the cuttings it is generally better first to cut away the roots of the seed sponges if they contain fragments of rock or coral or shells. Otherwise much time is lost through the dulling of the knives. For this rough work it is well to use a heavy knife with its edge serrated by vertically grooving the flat face of the blade with a three-cornered file, converting it into practically a sharp-edged saw. For making the actual cuttings large butcher knives of good quality should be employed, and they should be kept sharp by frequent whetting with a coarse stone, such as is used for sharpening scythes. A rather rough ragged edge is preferable to a smooth one. If the knife be in proper condition the sponges will cut as readily as beef liver, but if it be dull the operation is slower and the cuttings are liable to injury by the compression of their tissues under the knife.

The direction of the cuts will depend upon the size and shape of the seed sponge, but in the majority of cases the latter should be placed on a wet board, root down, and cut into slices from 1¼ to 1¾ inches thick, each of these being subdivided to best advantage as dictated by the judgment of the operator. It is desirable, but not essential, to leave on each cutting one surface covered by the uninjured skin of the original sponge. I have successfully grown cuttings taken from the interior of the sponge, but while the mortality is no higher and a new skin is soon formed over the entire surface, growth appears to be somewhat more slowly initiated than in the case of normal cuttings.

Neither the seed sponge nor the cuttings are injured by moderate exposure to the air, but it is safer, especially in hot weather, to throw the pieces into a tub of fresh sea water as soon as cut. Care should be exercised to change the water at intervals of about one hour, as the cuttings will be injured and probably die if left for any length of time in foul water and a few fragments of dead sponge will speedily contaminate a tubful. Neither the entire sponge nor the cuttings should ever be brought into water much below oceanic saltness and care should always be taken to protect the tubs from rainfall, which appears to have an effect disastrously out of proportion to its volume. If it is necessary to keep cuttings over night they should be placed in netting bags and hung in the open water, but they should never be so left more than a day or two, as they will soon grow together and be separable without injury only by the knife. Specimens left in contact for three or four days have grown into conglomerate masses difficult to handle.

ATTACHMENTS.

The chief problem confronting the experimenter in sponge culture is to find some ready and economical means of attaching the cuttings to a durable support which shall be capable of resisting the chemical action of sea water and the ravages of the teredo and other animals having similar destructive habits, and which at the same time is without injurious effect upon the sponges. During the course of the present experiments numerous materials and methods were employed, most of which sooner or later demonstrated their unfitness to fill the requirements. It was found that the cuttings would speedily attach to any firm, clean, innocuous material, and many methods of attachment appeared satisfactory for a year or two, but then developed some defect due to corrosion, tensile weakness, or the lack of sufficient attaching surface. It was necessary to await developments before the direction of further experiments was indicated, and much time was expended on materials which afterwards developed unexpected defects.

During the first season the cuttings were attached to stakes and rectangular frames laid on the bottom, to vertical stakes, and to pieces of coral rock and small copper wires laid on the bottom. Some of the sponges were threaded on the supporting copper wires and others were bound to them by means of short pieces of lighter wire, with the expectation that the sponge would eventually encompass its support. About six weeks after the plants were made it was found that 95 per cent had healed and were living under apparently healthy conditions, but seven or eight months later most of them had died. It was expected that the action of the sea water on the copper wires would produce poisonous salts, but in quantities so small as to have merely a local effect. It was found, however, that wires one-sixteenth inch in diameter were completely corroded away in places, especially where the cuttings were attached, and the latter were either killed, or lost by the breaking of the wires. The effects were especially pronounced when the wires were lying on the bottom. The cuttings placed on the bottom on rocks and stakes soon became covered with silt and vegetable growths and were either killed or lost, and it was evident that the choice of both materials and localities had been unfortunate.

During the winter of 1901–2 advantage was taken of the experience gained during the preceding year, and in addition to Biscayne Bay and Sugar Loaf Key, where the first year's experiments were made, Anclote Key was selected as an additional locality. Instead of using naked copper wires, various types of insulation were tried, other metals, including lead and heavily galvanized iron, and various cordage materials were experimented with, and molded forms of terra cotta, plaster, and cement were used in place of the rocks and stakes placed on the bottom. The more or less expensive insulations composed of

various patented compounds of rubber, etc., which have been found to possess superior properties for electrical purposes, soon developed their worthlessness for sponge culture, the insulation being affected by salt water and stripping from the wires. Underwriters' insulation, so called, a cheap covering of cotton and white lead, proved to be more durable and lasted for upward of two years, but it, too, eventually stripped or crumbled from the wire. Ordinary telegraph wire electrolytically galvanized rusts very quickly and breaks into pieces. Iron wire galvanized by the "hot process" will last for a number of years if kept fully immersed in sea water, but when it is periodically partly exposed at low water it rusts more quickly, and moreover the zinc coating kills that part of the cuttings brought into contact with it. Iron wire coated with lead is also quickly destroyed, and copper wire coated in the same way kills the sponges. Plain or "black" iron rusts quickly and breaks, and the iron salts are injurious to the fiber of the sponges. Aluminum wire is innocuous as to its salts in sea water, but is rather expensive when of sufficient diameter, and is subject to rapid corrosion in spots, causing it to break into pieces.

Asbestos cord was found to be practically indestructible chemically, but when wet the fibers become loose and frayed and so slippery that the tensile strength is seriously reduced. This difficulty was overcome by treating the cord with rubber solutions, white lead, a mixture of paraffin and asphaltum and other waterproofing and cementing substances. This treatment very greatly increases the strength of the cord, especially in the water, but the rubber is somewhat expensive and the asphaltum, despite its mixture with paraffin, has an abrasive effect on the cuttings and wears large holes where the cord passes through the growing sponge.

Jute, sisal, manila, cotton, and hemp lines were employed, but as expected, they were all quickly destroyed in salt water. Coir (cocoanut fiber) rope was not experimented with, as there was some difficulty in obtaining it, and moreover, experiments with the fiber showed that it, too, is more or less quickly rotted in the water.

Stakes and other wooden structures placed on the bottom are quickly riddled by the teredo and other boring organisms. If planted green with the bark on they will last longer, but the bark of the most durable, the mangrove, has a bad effect on the sponges, while that of other trees tends to scale off after a while; the sponges becoming detached with it. If there were no better method available, black mangrove and white wood stakes stripped of bark would probably hold together for four years, but to prevent rotation and capsizing they must be nailed together in frames.

To none of these materials, excepting the barked stakes, did the cuttings make organic attachment. When the artificial attachments loosened, the cuttings were free to rotate and drift on the wire, and when the latter was at

all rough, holes of considerable size were eroded in the sponge. Asbestos cord treated with rubber solution was least objectionable in this respect, owing to the softness of its surface and the firmness with which it could be gripped by the binding wires, the method of applying which is explained later.

It was found that this difficulty of the corroding wires was obviated by the use of lead wire, to which the cuttings speedily form organic attachment and cling independently of artificial aid. The tensile strength of this metal is so low, however, that in spans it will not support itself, to say nothing of the weight of the sponges and the pressures exerted by waves and currents. To secure the virtues of lead, its freedom from corrosion, its chemically inert and innocuous qualities, and the facility with which the cuttings grow fast to it, while at the same time eliminating its defect of tensile weakness, the device was adopted of employing a strong fiber or wire core encased in a thin coating of lead.

Several types of this construction have been employed with varying success. One of the earliest was ordinary tarred marline encased in lead about one thirty-second inch thick. This was light and when new quite strong enough for the purpose, but eventually the marline rotted and the lines broke, though some lasted for two years. Asbestos cord covered in the same way was also experimented with and found unsatisfactory.

Several forms of lead-covered insulated wires have been used, but the ordinary commercial sorts have been unsatisfactory, being either too heavy and expensive, or, if sufficiently light and cheap, lacking in durability. Commercial underwriters' wire with a copper core and specially encased in lead was superior to the higher priced insulations, and a still better wire was of the same type with the copper core replaced by galvanized iron. This had to be made to order, as there are no such insulated iron wires on the market.

All of these wires and lines were used in the same general way, stakes being driven in the bottom in parallel rows at intervals of about 25 feet and the wires suspended between to form squares. At first the wires were attached merely by tying or winding them about the stakes, but it was found that this rigid attachment caused them to break under the repeated flexure to which they were subjected by swaying in the waves. Later galvanized rings were placed over the stakes, four wires radiating at right angles from each toward the adjacent stakes, the whole being supported at a proper height above the bottom by means of a short wire attached to the stake and ring, respectively.

When lead-covered lines began to be employed they could not be attached directly to the rings on account of electrolysis, which would cause the iron to rust, and the rings were then wrapped with insulating tape to keep the two metals from coming in contact. Here another difficulty was encountered, the lead coating wearing through when loosely attached to the ring, or breaking near

the ring under repeated flexure when rigidly attached. In the latter case the insulation was abraded by the rubbing of the rough edges of the broken lead casing, and the exposed core broke by the concentration of flexure at the weakened point, or else, coming into contact with the lead, was destroyed by electrolysis.

To overcome this, horseshoe-shaped porcelain pieces were interposed between the rings and the wires, as shown in figures 1 and 2. By this means the electrically antagonistic metals were kept apart and at the same time there

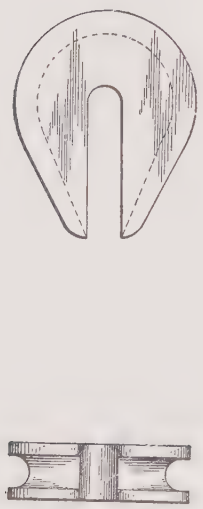

FIG. 1.

FIG. 2.

FIG. 1 AND 2.—Showing insulated attachment for lead-covered lines supporting sponge cuttings.

was formed a rocking attachment without wear on the lead, the flexure of the wire being distributed throughout its length instead of being concentrated near the stakes.

With galvanized iron wire with underwriters' insulation and incased in lead, this device served very well so long as the sponges were not much over 4 inches in diameter, but when they grew larger there was a contingency which had not been anticipated, the sponges being torn loose and rotating on the wire. Practically all of the wires used were less than one-fourth inch in diameter, a larger size being objectionable on account of its weight and the hole produced in the

sponge. This gave a small surface of attachment which, while sufficient at first, became proportionally smaller as the sponge grew. The attached area, and consequently the strength of the attachment, grew proportionately to the diameter of the sponge, while the forces acting to loosen it grew in proportion to the surface exposed to the impact of the waves. The consequence was that in rough water sponges 5 inches in diameter were generally torn loose, and, once started to rotate or oscillate, a large hole was soon worn about the wire to the detriment of the quality of the sponge and the retardation of its growth. In sheltered places sponges were successfully grown on wires until they reached a diameter of 7 inches, but eventually they also must have become loose.

To correct this tendency to loosen, the shape of the wire was modified to assist the strength of the attachment by mechanical resistance to the rotation of the sponge, longitudinal slipping on the wire being negligible after the attachment of the cutting is once established. A galvanized iron ribbon three-eighths inch wide and one-sixteenth inch thick was incased in a tight-fitting lead jacket one thirty-second inch thick, the whole making a flat band one-eighth inch thick and not quite one-half inch in breadth. This appears satisfactorily to prevent rotation in sponges as large as 8 inches in diameter.

This lead-incased ribbon is durable so long as the casing is not mechanically broken or punctured. At the cut ends the iron rusts away slowly, but the contact between the iron and the lead is so intimate that the water at a depth of 10 or 12 feet penetrates but an inch or two at most, and electrolysis is, therefore, strictly localized to the open ends. It has to be handled with care, however, as the thin lead is easily punctured and the slightest hole becomes the seat of electrolytic action to the speedy destruction of the iron and the consequent breakage of the ribbon. When carefully put out this material has lasted for three years with no other sign of impairment than the rusting away of about one-half inch of the iron where exposed at the ends. Its strength is great, as was demonstrated at Biscayne Bay during the great hurricane of 1906 when a piece of wreckage fouled some of it, pulling up deeply embedded stakes and flattening a ¼-inch wrought-iron ring without injuring the ribbon. It is heavy and difficult to handle when planting from a small boat and there is also some difficulty in attaching it at the stakes. It, of course, can be bent in but one plane, and it can not be attached directly to the rings owing both to the electrolytic effect upon the latter and to the abrasion of the lead casing of the ribbon.

In the experimental work porcelain insulators were attached to the rings by means of galvanized wire, the ribbon being bent over them, with a piece of thin sheet lead interposed, and secured by means of a flattened seine lead or piece of lead piping as shown in figure 2. In a commercial application a special insulator similar in general shape to that shown in figure 1 could be employed. In any case it is necessary to place a piece of sheet lead or asbestos

cloth between the porcelain and the ribbon to prevent wear and tear on the lead covering of the latter.

All of the foregoing experiments were made with a view to the utilization of soft muddy or grassy bottom upon which sponges will not grow naturally and in depths not exceeding 10 or 12 feet. This would have made possible the utilization of considerable areas among the keys and close to shore along the Gulf coast, in localities where the plantations could be readily protected. The results of the work, however, have failed to disclose a material which is satisfactory in all respects. The lead-covered iron ribbon if carefully handled and planted with its casing uninjured has sufficient durability and prevents the loosening of the sponges as they reach commercial size, but it is not a commercial product and has to be made to order, which militates against its use by small planters, while its weight makes it somewhat difficult to handle in lengths of more than 15 feet, this, in its turn, increasing the cost of stakes, rings, and attachments. The rings and insulators will last indefinitely, the stakes will have to be renewed once during the growth of the sponges, and the indications are that the ribbon, or at least most of it, will not be useful for a second planting. Lead-incased galvanized-iron underwriters' wire about one-fourth inch in external diameter with no. 12 Brown & Sharp gauge core is durable, costs about one-half as much as the ribbon, is easily handled, and much of it can be used for a second planting, but on account of its circular cross section the sponges as they grow will loosen and rotate in any but the most sheltered places.

The value of a method which would permit of the utilization of otherwise useless and barren bottom in shoal water is great and warrants further experiment, but the results so far obtained are not such as would justify the recommendation of any of the methods or materials experimented with. The experimental results of the work with wires are valuable on account of the facility with which the sponges could be examined and the data which it has been possible to obtain as to the rate of growth, the mortality, and the general behavior of the cuttings.

As has been mentioned, in the very beginning of the work experiments were made with various bottom attachments. The use of stakes or poles has already been discussed and the objections stated. They never offered much encouragement for further trial. The plaster, cement, and pottery forms first employed were about 5 inches in diameter on the bottom, 4 inches on top, and about 1½ inches thick. The larger face was slightly convex, and the smaller, to which the cutting was attached by means of a V-shaped wire running through a central hole, was flat. They were found to be too small, tending to capsize as the sponges grew and offering greater surface to the impact of waves and currents, and there was also some difficulty with silt and vegetable growths which

interfered with the welfare of the cuttings so that they were also difficult to keep under observation for experimental purposes.

Owing to the encouraging early results and the apparent advantages of the wire suspension methods previously described, provided a suitable material could be obtained, work with bottom planting was suspended for several years but was taken up again in 1905 when it became apparent that none of the lines and wires previously experimented with was likely to prove satisfactory. About the same time a sudden disaster, due to the presence of drainage water near the surface on the plantation at Anclote key, made it necessary to transplant hurriedly the remaining sponges to the bottom in another locality. Not only the plantation of the Bureau of Fisheries was affected, but also that of Messrs. Cheyney and Bigelow, who on an adjoining site had been, for two years preceding, conducting a similar experiment on a commercial scale.

Bricks, rocks, and anything available were first used in the hurry to remove the sponges from untoward influences, but in the meantime there were being made a number of cement disks larger and heavier than those used during the first two years of the experiment. These disks (pl. LXVIII) are about 10 inches in diameter and 1¼ inches thick, and are composed of a mixture of 1 part cement to 3 or 4 parts sand. They are molded in iron rings of the required dimensions laid on the sand, and two holes about 4 inches apart are made in each by thrusting through the cement before it hardens an iron bar three-eighths inch in diameter. The molds are removed as soon as the cement has set and before it hardens, the operation being facilitated by running a thin-bladed knife around the inside of the rings to break their adhesion to the disk. The disks can be made by this method for less than 2 cents each, including material and labor.

For experimental work hollow triangles (pl. LXVII) were substituted for the disks, six sponges being planted on each. As each triangle was marked or numbered, record could be kept of the growth and behavior of the cuttings, and as the large triangles were less easily overlooked than the smaller disks and as each was planted with a definite uniform number of cuttings, the rate of mortality could be readily determined from time to time.

These disks and triangles are satisfactory on rocky bottom, but tend to bury on sand, marl, or soft mud. They may, however, be used on bottom with a sparse growth of grass. When the grass is long and dense it tends to fall over the sponges, causing death or irregular growth. Where shifting sands and silt are carried by the currents these materials tend to deposit in the eddies on the lee side of the disks and triangles, and eventually pile up around the base of the sponges and kill them. To obviate this difficulty spindles were placed in some of the triangles (pl. LXVII) and disks, six in each of the former and one in the latter, the cuttings being attached near their tops so as to prevent free flow of the currents beneath. These spindles project about 8 inches and various materials were tried,

the most satisfactory being short lengths of the lead-covered iron ribbon before described. They serve the purpose perfectly, they are sufficiently durable, the sponges soon permanently attach, and no suffocation occurs in places where cuttings on the disks would be buried in mud or sand. The spindles are, however, about double the cost of the disks, and although the indications are that if carefully handled they will last long enough to mature two crops of sponges, they eventually will be destroyed while the disks are practically indestructible. The spindles also prevent close packing of the disks and are more troublesome to handle, but on the other hand they facilitate the attachment of the cutting, as will be hereafter explained.

PLANTING.

The method of applying the cutting to the support has undergone gradual modification. In the early experiments with various insulated wires, when the sponge did not form organic attachment, the pieces were bound against the supporting line with short pieces of aluminum wire thrust through the sponge and twisted around the support. It was found that the cuttings were often slow in growing around the support and should the binding wires become loose were likely to be detached and lost. To obviate this difficulty the expedient was adopted of slitting the cutting, placing the two legs of the slit astride of the supporting wire and binding the several faces in close apposition by means of rubber bands or short aluminum wires traversing the two flaps of the cutting and at their ends twisted around the supporting wire. Under such conditions the slit speedily fused and the cutting became organically intact about the wire. Aluminum was employed for binding because its salts in sea water are neither rapidly produced nor injurious.

With the use of lead-covered materials, to which the sponges grow fast, it became possible to "thread" the cuttings on the wire, the use of binding wires being unnecessary to hold them in position. To facilitate this operation needles (text fig. 3) were made of clock-spring steel, one end being shaped to a sharp stiletto point, and the other rolled or folded over to form a socket fitting the end of the wire on which the sponges were to be planted. In planting, the needle was fitted to the wire and the cutting pierced by the sharp end of the needle and pushed onto the wire as one would use an ordinary needle and thread in stringing beads. After attaching the ends of the wires to the stakes the cuttings were distributed at regular intervals by sliding them along with the hand, their friction against the lead usually holding them in place until organic attachment occurred. Several mechanical distributers were devised and experimented with, but none was very satisfactory.

In planting on plain disks the cuttings are pierced by short aluminum wires, the ends of which are carried through the two holes already described and twisted

Fig. 1.

Fig. 2.

CEMENT DISKS WITH CUTTINGS NOT SET IN. FIGURE 1 SHOWS SPINDLE ATTACHMENT; FIGURE 2 SHOWS CUTTING SECURED BY WIRE.

on the under side (pl. LXVIII, fig. 2). This is a rather slow process, and it is not possible for two men to cut, attach, and plant more than about 100 cuttings per hour. To accelerate the speed of planting I have placed in the center of each disk a short spindle of ¼-inch lead wire, slightly flattened at the top by a blow from a hammer and projecting to a length of about 2½ inches (pl. LXVIII, fig. 1). About 8 or 10 cuttings are placed on a long needle (fig. 3) of the required shape, the socket of which is placed upon spindle after spindle in succession and the cuttings pushed into place in contact with the cement base, each with a single motion of the left hand. Friction of the slightly stretched tissues against the spindle and the burr at the top of the latter prevent the detachment of the cutting, which in a few days grows fast to both the spindle and the disk. With this device two men can plant from 250 to 300 cuttings per hour, and this gain in speed over the other method is highly important in places where rough weather is prevalent, as it makes possible the fullest utilization of such opportunities as present themselves. The spindles add about 25 per cent to the cost of the plain disks, but as they will survive a number of plantings this cost is compensated for by the decreased cost of labor.

FIG. 3.—Needles used for threading cuttings on supporting wires.

This system also facilitates replanting with cuttings at the time of harvesting of the first crop, as the grown sponges can be quickly detached and new cuttings substituted. In shoal water where the sponges can be taken with hooks, two additional men in the boat should be ample to detach the sponges and replant the disks as rapidly as they are brought up. In deep water where a diver has to be employed for harvesting the crop, the cuttings can be taken down by the diver and planted as the matured sponges are removed, avoiding the labor and inconvenience of bringing the disks to the surface, and reducing the cost of operation very much more than sufficient to cover the increased first cost of the disks.

The expense of labor in deep-water planting is of such importance that the strictest economy of operation, especially in taking up the sponges, must be given careful consideration. The diver's time must be economized, as the time of the entire crew of the diving boat is dependent upon the rapidity and

efficiency with which he works. The attachment of sponges to the disks by means of wires is slow under the best conditions and must be much slower under water where work is done at a disadvantage, but the cuttings can be slipped on to the spindles as readily under water as in the air.

The same considerations apply to cuttings planted on long spindles (pl. LXVII) which will hold them above the bottom and in deep water. Especially in a locality requiring the transport of the disks or triangles for considerable distances, the second planting can be carried on more economically than the first. Holes should be punched in the disks, however, even when spindles are used, so that a wire attachment can be employed should the spindle eventually be broken off.

The density with which sponges can be planted on the bottom in any given locality is a subject which will require actual experiment on a commercial scale for its elucidation. That ordinary waters will support a dense growth of miscellaneous sponges is well known, and among the Florida keys I have observed an average of several to a square yard over considerable areas.

Though nothing is known of the actual facts concerning the food of sponges, it can hardly be doubted that all horny sponges feed on essentially similar material. If this be true, it is fair to assume that an area which will support a large number of useless horny sponges should support and produce an equal volume of the commercial kinds. Unfortunately the shoal-water beds of our coast are now so depleted that present day observations are useless and the distribution of the valuable kinds on the deep water grounds is so unequal, owing to the irregular and sporadic occurrence of suitable bottom, that nothing definite can be learned. I am informed by Dr. H. M. Smith, however, that in very shoal waters in the Philippine Islands he has seen commercial sponges somewhat similar to the Florida grass sponge averaging one to every square foot of the bottom over areas many acres in extent. The commercial experiment carried on at Anclote Key by Messrs. Cheyney and Bigelow showed that, even in an unfortunately selected locality, cuttings would grow rapidly when planted with a density of about one per square yard over an area of about 15 acres, and that the growth was no less satisfactory than upon the government's neighboring plantation covering but a few acres. In no case, on any of the plantations under observation, did the density of planting, up to a maximum of a little over one sponge per square yard, have any apparent effect upon the rate of growth. In bottom planting on a small scale sponges have been planted in some cases as densely as 5 or 6 per square yard without apparent bad effect, but with extensive areas so thickly planted it is possible that there might be an insufficiency of food. Experiments in Biscayne Bay appear to indicate that sponges grow more rapidly in strong currents, and presumably the same condition would permit denser planting than where the currents are weak.

RATE OF GROWTH.

(Plates LXIX to LXXVI.)

The rate of growth of cuttings is a matter of paramount practical importance to the prospective sponge culturist, and it has been the subject of considerable discussion and difference of opinion. The fishermen variously claim that on the natural beds sponges grow to a "marketable size," presumably 6 or 7 inches in diameter, in from six months to a year, basing their statements on the fact that grounds supposedly denuded one year are found to bear salable sponges the next. They fail to consider the certainty that they have overlooked a number of large specimens and numerous small ones already well on their way to merchantable size. Smith, in his paper, "The Florida Commercial Sponges," basing his statement upon the reports of others, says that the claims of the spongers are borne out by experiments, and that "in as short a time as one year, under favorable conditions, the cuttings will attain a marketable size, and certainly within sixteen or eighteen months the harvesting of relatively large sponges may be depended on." To substantiate the statement he furnishes a photograph, a careful inspection of which creates the impression that the photographer has somewhat assisted nature in establishing the apparent rate of growth. I have reason to believe that both Dr. Harris, the grower of the sponges in question, and Dr. Smith were deceived as to both the age and the origin of the larger specimen, and that it came from a mangrove root and not from a wire, as supposed. As photographed it is about 5½ inches in diameter and is said to be not over eight months old, but I have seen a number of other sponges planted at the same time and place and under the same conditions which had attained a size of not over 4 inches when between three and five years old. They were all planted under unfavorable conditions, and the best result that I have been able to attain in the same locality and under better conditions of growth was an equal diameter in about two years from cuttings between 2 and 2½ inches cube.

The experiments by Fogarty at Key West about 1880 have not been accurately or definitely reported, but it is said that cuttings about 2½ inches in diameter in some cases increased from four to six times in bulk within a period of six months. This is more in accord with my own experience, though, as will be shown later, the relative increase in volume is greater with small cuttings than with larger ones.

The results obtained by Buccich are also out of accord with the popular view of the rate of growth of sponges under natural conditions, although the reports of his work are lacking in definiteness. His cuttings, about 1 inch cube, increased to two or three times their original bulk in one year and did not reach full marketable size, the exact dimensions not being stated, until the lapse of seven years, a much slower rate of growth than in Florida.

My own experiments show that the raw surfaces of cuttings become pigmented within a few days and that at the end of a month they have completely healed and have begun to grow and project little papillæ or cones. Sharp angles and edges generally die and slough off slightly, and the central portions of the plane faces become swollen so that at the end of three months in small cuttings and somewhat later in larger ones there is evident a distinct tendency to rotundity. At the end of six months in many specimens the cut faces can not be distinguished from the original surface of the sponge and in practically none can they be determined except by the shape. In all cases there is a constant tendency toward a spheroidal or ellipsoidal shape, cubical cuttings approaching the former and irregular ones the latter form if suspended above the bottom, but all becoming cake-shaped if grown from basal attachments. (Compare plates LXXIV and LXXV.)

Growth takes place in all directions with approximate equality when the cuttings are suspended freely in the water, but is generally more rapid in the horizontal plane when the sponge is attached to a basal support. If the cutting be attached to a small horizontal surface it will grow downward over the edges, and if the surface be uneven it will project itself into all the irregularities and holes. For this reason, if basal attachments are used, it is desirable to have them with smooth surfaces and of a horizontal expanse greater than that of the sponges which it is desired to grow, otherwise considerable weight, and also time, is lost in trimming the marketable specimens to a desirable and uniform shape.

Buccich observed considerable variation in the rate of growth and my own experiments confirm his statements. Cuttings which, so far as could be determined, were similar in size, shape, and character, diverged widely from one another in this respect and some of them, while healing completely and remaining in an apparently healthy state, had grown hardly at all in the course of several years. In some cases cuttings made from the same sponge exhibited this diversity. Different lots of cuttings of the same average size and planted in the same locality exhibited a remarkably uniform average rate of growth year after year. In Sugar Loaf Sound the average annual increase in diameter was about 0.8 inch, while at Anclote Keys and Cape Florida it was from 1 to 1.2 inches. In Sugar Loaf Sound this average was maintained to the end of three years, when the experiment was abandoned for reasons already explained, while at the other two places it continued until the end of four years, when accurate records were lost as the result of disasters due to meteorological causes.

Recent developments in Biscayne Bay indicate that the average growth of sponges planted on the bottom in Cape Florida Channel is slightly in excess of the rate stated above, while at Soldier Key, about 7 miles away, it is much less. At the first locality the currents are strong, the bottom muddy, and the neighboring

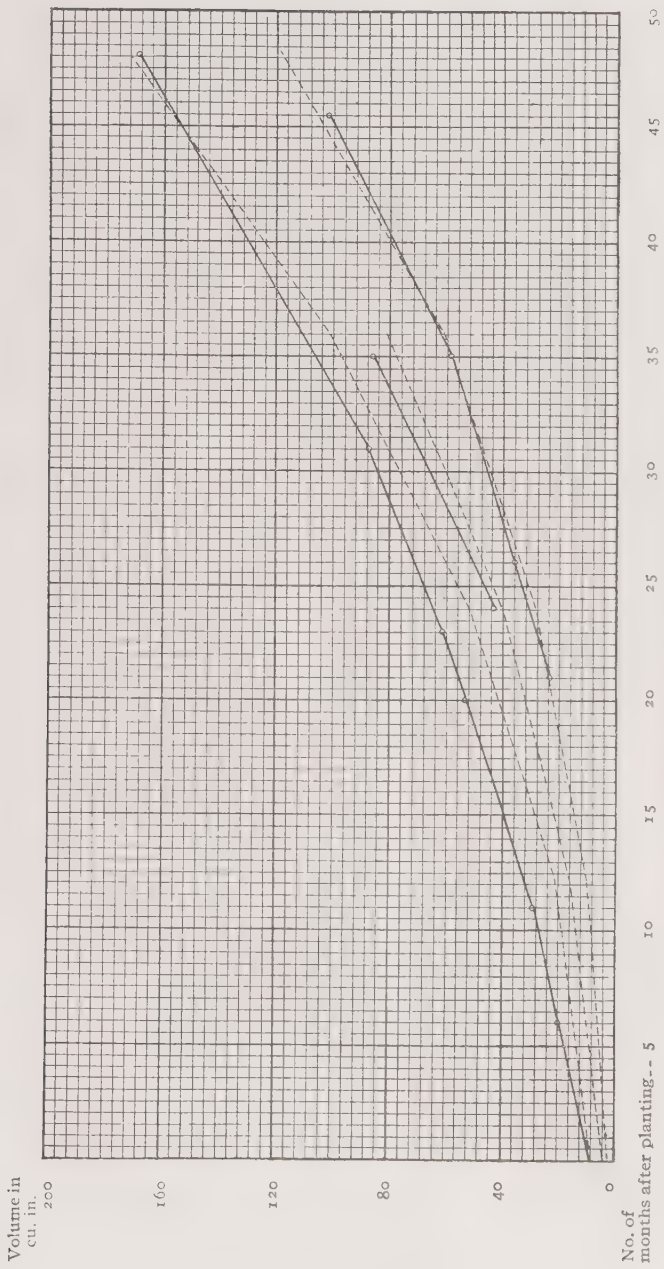

FIG. 4.—Average rate of growth of sponges from cuttings of several sizes. Anclote Key.

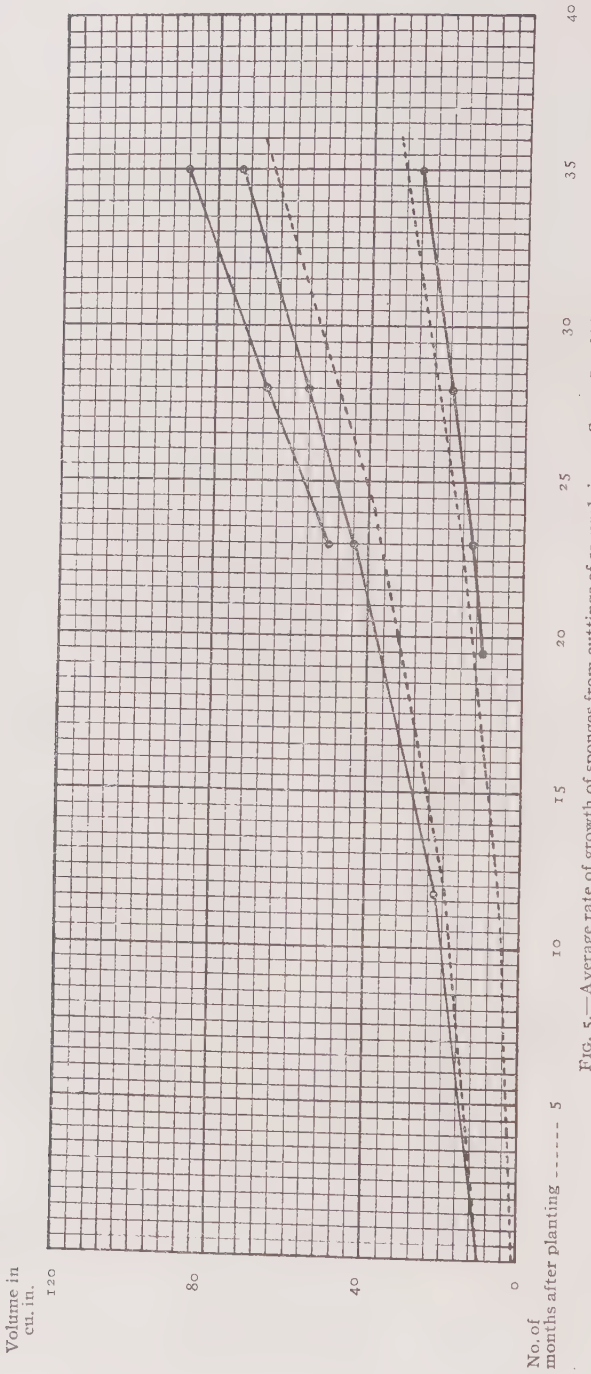

FIG. 5.—Average rate of growth of sponges from cuttings of several sizes. Sugar Loaf Key.

banks covered with vegetation, while at Soldier Key the bottom consists of clean rock, the adjoining banks are sandy, and the current is probably less rapid, though of the latter I am not certain. The difference in the rate of growth may be due to the strength of the current or to the larger amount of food in the waters adjacent to marine vegetation. That the latter is the probable reason is indicated by recent observations that sponges planted on bottom covered by short grass at Soldier Key exhibit a more rapid rate of growth than those planted on bare rock.

The slower rate of growth in the warmer waters of Sugar Loaf Sound was a surprise, and it may possibly be accounted for by the general absence of strong currents or by the character of the seed sponges. These were all small specimens rarely over 5 inches in diameter, obtained from the waters of the sound, which while formerly producing large ones now rarely do, possibly as a result of overfishing in former years. In these shallow waters the spongers have been able rigidly to select out all marketable sponges, a process which would logically tend to eliminate those which grew rapidly and had an inherited tendency to reach larger dimensions, while leaving a preponderance of those of slower or stunted growth to perpetuate their kind. The inevitable tendency of an intensive fishery of this character would be to breed a race of more or less dwarfed sponges of slow growth, an assumption which is in a measure confirmed by the fact that Sugar Loaf Sound formerly produced a much greater proportion of large sponges than it does at present. This could not be due to the intensity of the fishery during the period within which I have been familiar with it, as the sound was then closed to promiscuous fishing and the sponges had ample opportunity to grow to larger size than the average attained.

In Biscayne Bay and at Anclote Key the seed sponges were obtained from partially depleted beds, but owing to the greater depth and the more frequent prevalence of turbid water these have never been so thoroughly scoured of marketable sponges. The specimens from which cuttings were made were larger, and presumably more virile, and in any event the cuttings grew more rapidly. At Sugar Loaf and Anclote Keys the planted sponges were measured at intervals after the first year by means of calipers, and occasionally specimens of average size were taken and cleaned. In Biscayne Bay local conditions prevented the systematic measurement of the sponges while growing.

Text figures 4 and 5 exhibit graphically the rates of growth in volume of the cuttings at Anclote Key and Sugar Loaf Sound, respectively. The dotted lines indicate the theoretical increase in volume, assuming a uniform annual increase in diameter of 0.8 inch at Sugar Loaf and 1 inch at Anclote Key, while the heavy lines show the average growth of a number of measured specimens of the ages indicated by the position of the small circles. It will be observed that the

growth is fairly uniform up to the end of the fourth year, when there is a tendency to drop, but whether or not this late decrease in the rate is normal can not be stated, as the specimens measured had been injured by an influx of fresh water on the plantation.

The experiments with wires appeared to show that sponges suspended above the bottom grow more rapidly than those on or near the bottom, but more recent results with disks and triangles appear to throw some doubt on this. It is probable that dense vegetation among which the sponges lay had an inimical effect and that sponges planted on bottom where they would not be covered by vegetation would grow as rapidly, or nearly so, as those suspended above it. With bottom planting it is difficult to make accurate and systematic observations on a large scale, but such observations as have been made at Biscayne Bay and Anclote indicate that the rate of growth of cuttings planted on disks and spindles is at least equal to that of sponges planted on wires.

The question has been raised in regard to sponge culture whether if a sponge be cut into pieces the total growth of the pieces will be greater than the increase of the same sponge would have been if it had remained intact, the environment being identical in the two cases. It has been argued with some plausibility that the reply to this question is in the negative, but experiments at Sugar Loaf Key do not bear out this assumption, and it was determined that entire sponges from 2½ to 4½ inches in diameter grow at approximately the same rate as healed cuttings of the same volume each. They both increased in diameter at the average rate of about 0.8 inch per year, some individuals in each exceeding and some falling short of the average. The greater aggregate increase in volume, therefore, is obtained by cutting the sponges into pieces, and the smaller the cuttings, provided the minimum heretofore stated is not passed, the greater the advantage of subdivision. This is expressed graphically in figure 6, where the solid line represents the growth of an entire sponge 6 inches in diameter, and the broken line the aggregate growth of a sponge of the same diameter cut into 20 and 50 pieces, respectively, making an allowance of 5 per cent per year for mortality. The same data are shown in the following table.

COMPARATIVE INCREASE IN VOLUME OF AN ENTIRE SPONGE AND THE AGGREGATE OF CUTTINGS FROM SPONGES OF EQUAL VOLUME.

	Volume when planted.	1 year.	2 years.	3 years.	4 years.
	Cu. in.	*Cu. in.*	*Cu. in.*	*Cu. in.*	*Cu. in.*
Entire sponge	168	244	343	464	629
20 cuttings	168	399	738	1,287	1,952
50 cuttings	168	446	1,035	1,932	3,200

It will be seen that at the end of four years the volume of 20 cuttings made from a 6-inch sponge will be over three times that which the same sponge entire would have attained under the same conditions, while 50 cuttings made

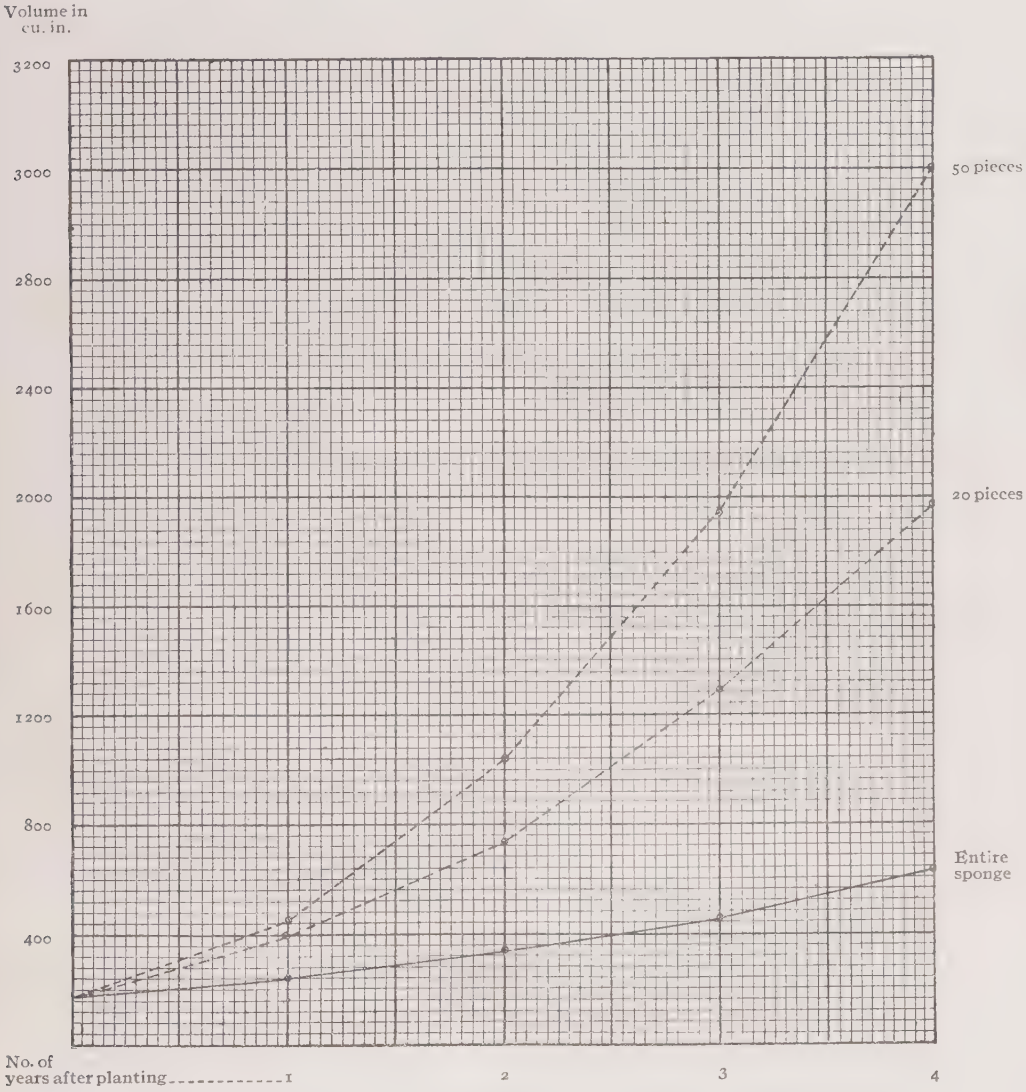

FIG. 6.—Comparative increase in volume of an entire sponge and of the aggregate of cuttings from sponges of equal volume.

from a sponge of the same size will have a volume nearly 5 times as great. It should be explained, however, that these data do not represent a concrete case, but are based on observed rates of growth of cuttings and entire sponges under the same environment. The experiment begun to demonstrate these facts was interrupted by theft and vandalism.

It should be stated also that 50 cuttings made from a 6-inch sponge would be smaller than has been found advisable and the rate of increase in diameter during the first year would be somewhat smaller than has been assumed, though thereafter it would be fully equal to that of the larger cuttings.

MORTALITY.

The data upon the highly important question of the death rate among sponges grown from cuttings are not satisfactory. Buccich estimated it at about 10 per cent in seven years, but my results indicate a somewhat higher rate.

Owing to the unsatisfactory character of the supports which were employed during the early years of the experiment, it was necessary to shift the sponges from time to time, each handling resulting in some loss, and moreover the breakage of the lines often allowed the plants to fall to the bottom, where they were much injured by adverse conditions. The mortality was highest at Anclote Key, where the plantation was exposed to the full force of the waves and the parting of the lines was frequent, and it was least at Sugar Loaf Key, where the greatest shelter was afforded. At Anclote there also was always more or less fall in the salinity during the heavy rainfall of summer, and the greatest mortality on the lines which remained intact was invariably coincident with this. Cuttings planted in the fall frequently reached the late spring months with a mortality of but 1 or 2 per cent, a rate increased to 8 or 10 per cent by fall. The observations made at that place are of value only as indicating the necessity for establishing the plantations in places not subject to the influence of freshets in neighboring streams. At Cape Florida, in Biscayne Bay, the plantation was more sheltered from boisterous seas, but the surface water was liable to fall in salinity during summer with a coincident increase in the death rate, though here the results were not so uniform. At this place various lots of sponges planted at different times and all subject to more or less of the vicissitudes of experimental work mentioned above, exhibited mortalities of 32 per cent at the end of fifty-three months, 29 per cent at the end of forty months, and 15 per cent at the end of twenty-six months, respectively. The first two lots were subject to damage from the breaking of the wires, but the last did not have this condition to contend with and the mortality during the last twenty-one months was equal to but 4 per cent of the original number planted. The heavy death rate of the first five months was due to the sagging of the wire so that the cuttings lay among the dense vegetation, none of those raised above the top of the grass dying during that period.

At Sugar Loaf Sound no difficulty was experienced with fresh water, and the death rate was correspondingly decreased. The lot of 400 cuttings having the longest period of growth at that place—thirty-five months—exhibited at the end of that time a mortality of 14 per cent. All of these were transplanted at

least once after having lain for an unknown time on the bottom vegetation under conditions which other experiments have shown to be inimical, and a considerable proportion of the deaths occurred at those times. Had the wires remained intact and the cuttings been kept always suspended above the vegetation the death rate at the end of three years would undoubtedly have been

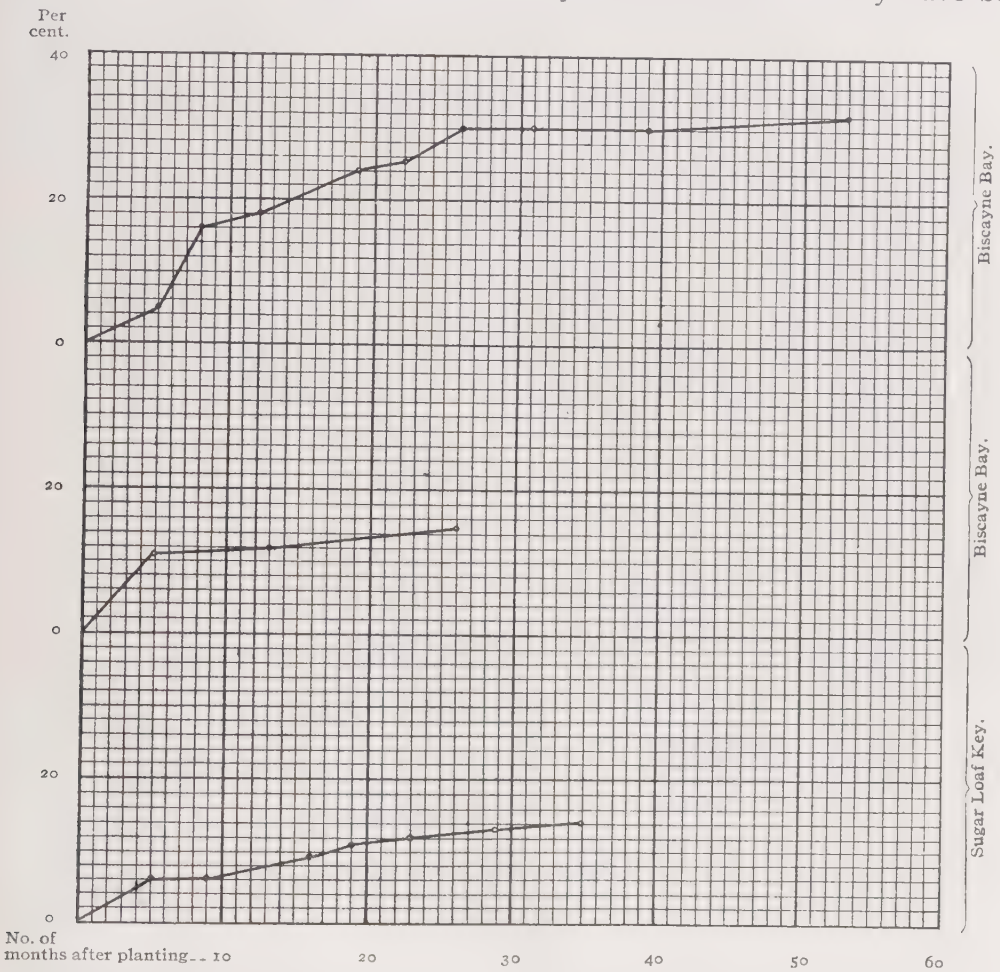

FIG. 7.—Percentages of mortality among different lots of sponges grown from cuttings at Sugar Loaf Key and Biscayne Bay.

under 10 per cent. Curves showing the percentage of mortality among different lots of sponges at Sugar Loaf Key and Biscayne Bay are shown in figure 7. These sponges were all on wires suspended above the bottom.

At Anclote Key, owing to the almost constant turbidity of the water, it has been found impossible to determine the mortality among sponges planted on the bottom. At Cape Florida, in order to obtain data on this point and to

avoid the error due to the liability to overlook disks from which the sponges may have become detached, practically all sponges planted on the bottom were attached to triangles either with or without spindles, each holding six cuttings. At that place the mortality at the end of six months was less than 3 per cent, and at the end of nineteen months a little less than 6 per cent, the latter including a few sponges in shoal water evidently detached by being fouled by the centerboard of a boat, and at thirty months 9 per cent. At Soldier Key, also in Biscayne Bay, the death rate among sponges planted on triangles on smooth rock bottom was about 3 per cent at the end of ten months. Data relating to bottom planting for longer periods are not available, the first extensive experiment in this direction having been destroyed by the great hurricane of 1906.

From the results recounted it is believed safe to assume that in localities free from influx of fresh water and the extensive deposit of silt or sand, with sponges planted on disks or triangles on rocky bottom, or on other bottom free from vegetation and stable enough to prevent the gradual sinking of the attachments, the mortality will be well below 5 per cent per annum.

SHAPE AND QUALITY.

Under artificial culture the shapes of sponges may be modified more or less to suit the special requirements of the arts. Sponges grown on wires or spindles assume a spheroidal shape with a uniform texture of surface and devoid of any semblance of a "root," such as is found in all natural sponges excepting rollers. This form is very attractive and durable.

Cuttings grown on disks tend to assume a flatter shape and the surface attached to the cement is plane, in that respect resembling the root of natural sponges, but instead of being "raw" and exposing the canals it is covered with a close soft felt of great strength and durability, and forms the strongest instead of the weakest part of the sponge (pl. LXXVI).

In certain arts and trades sponges with flat surfaces are required and to obtain these it is customary to cut the entire "forms" into pieces. The raw surfaces exposed in this way lack the durability of the natural surface and to obtain the latter, while at the same time retaining the several flat faces and sharp angles of the "cuts," a modified form of disk was employed. In this there were two partitions raised to a height of 4 inches, crossing one another at right angles on the upper surface of the disk. This left at the center of the disk four angular compartments, and in each of these a cutting was planted, which, being limited on three sides by the disk and two partitions, respectively, grew into a form having three plane surfaces at right angles to one another and one convex surface. The latter is similar in texture to the outside of an ordinary sponge, but the plane faces form contact with the disk and partitions and

develop a smooth, soft, and very durable felt-like surface. These sponges cost more to grow than those of ordinary shape, but experiments recently inaugurated will probably make the additional cost of production trifling. The superior durability of sponges grown in this manner should make it possible to market them at a price considerably above that brought by the natural product.

It has been found that the sponges grown suspended above the bottom are superior in density and closeness of fiber to the natural sponges from the same locality. The same superiority is not apparent in those grown on disks, but the absence of the torn surface or root which characterizes the natural product makes them much more durable than the latter, the close felting of the attached surface making it the softest and strongest part of the sponge. In other words, the place of greatest weakness is converted into that of greatest strength, while the other parts remain normal. The artificially grown specimens are always superior to the natural product of the same immediate locality.

At Anclote Key a considerable proportion of the sponges grown on the bottom are affected with so-called crab holes, cavities which commonly contain small crabs. The general opinion of the spongers is that the crustaceans produce the holes, but of this I am by no means assured. As has been explained heretofore in this paper, practically all of the sponges planted on the bottom in this locality were previously injured by fresh water and already bore patches of dead tissue when planted on the bottom. As these dead areas sloughed away they left cavities, and I believe that these invited the crabs, which thus did not actually excavate their hiding places. In the many hundreds of these crab holes which I have examined in both artificially and naturally grown sponges I have never seen the slightest indication of a raw surface which looked as if the crab had torn away the tissues of the sponge. The presence of the crab, however, undoubtedly prevents the hole from filling up as it would tend to do under other conditions. In none of the healthy sponges planted on the bottom in Biscayne Bay do these holes occur, though they are found in the usual proportion in the natural sponges of the vicinity.

HARVESTING.

With the wire method of suspension from stakes, if such can be commercially developed, the problem of gathering the crop is simplified, for all that is necessary is to detach the wire at one end and slide the sponges off. As has been shown in the foregoing, however, this method has not yet been perfected and can hardly be commercially considered as yet.

With bottom planting on disks or spindles the method of harvesting will vary with the depth of water. In comparatively shallow water the crop can be taken up when matured by means of hooks, and the conditions essential are

the same as for ordinary sponging—the weather must be moderate and the water clear. In deep water, beyond the reach of the hooks, it will be necessary to employ divers to gather the sponges, which will materially increase the capital required and the expense of operation. As has been explained previously, the operations of harvesting and replanting can be economically combined.

TRANSPORTATION AND ACCLIMATIZATION.

The transportation of seed sponges by water has been dealt with in another connection, but experiments indicate that they can also be carried considerable distances overland if proper precautions be observed. With the air temperature ranging between 70° and 80°, specimens have been easily kept without injury by merely packing them in wet seaweed in tubs. Others have been shipped by express, closely packed with wet eel grass and gulf weed (sargassum) in orange crates, over distances requiring three days between the time of removal from the water and the time of replanting. Although carried in heated express cars they were absolutely uninjured and started growth immediately after transplanting. Of another lot shipped on a six days' journey under the same conditions nearly all were killed.

If kept cool, the sponges will live much longer, and there is reason to believe that if carried in moist packing in refrigerator cars there would be little doubt of their surviving a trip extending over one week. Thus, with proper arrangements Florida sponges could be carried alive to the California coast. With similar arrangements and with the facilities which would be afforded for giving the sponges occasional refreshing baths in sea water it is believed that little difficulty would be experienced in carrying specimens from the Mediterranean to Florida. The water used in moistening the sponges and the packing material must be of full oceanic salinity, an experiment having shown a mortality of 50 per cent among sponges sent on a three-day journey when a portion of the packing material was inadvertently moistened with nearly fresh water from Anclote River.

But while there may be little difficulty in transporting sponges to distant places and acclimating them in suitable waters, there is grave doubt if they will retain the characteristics which they exhibit in their original habitats. Sponges from the vicinity of Anclote Key transplanted to Biscayne Bay undoubtedly gradually developed some of the characters of indigenous specimens, but unfortunately the experiment to determine this point conclusively was seriously interfered with by a hurricane which intermingled the various lots. All of the transplanted specimens which could be definitely identified, about 15 in number, had completely lost their original characteristics at the end of two

years, and it is probable that one not knowing their history would be unable to distinguish them from those grown from indigenous seed. The close-set bristles which cover the surface of wire-grown sponges at Anclote have been replaced by flat brushes of fiber, the oscula, formerly inconspicuous, have become larger and resident on the summits of short tubular processes, the general texture of the sponge is more open, and, finally, the fibers have become thoroughly charged with the characteristic red color of the Key sponges. In some specimens the red coloration is more pronounced than is normal in the locality to which the sponges have been transplanted.

At Anclote, also, it was observed that whatever the source of the seed there was a strong tendency of the plants to advert to a common type, though there appeared to be a tendency to compromise between the influences of heredity and environment. Deep-water sponges a year after the cuttings were planted assumed the bristly appearance above referred to, but the processes were shorter and blunter than in sponges grown from shoal-water seed. The texture of the skeleton was also closer and more dense than in the cuttings of shoal-water origin, but neither resembled very closely the sponges from which they were derived. With these facts in view, it is almost certain that Florida sponges transplanted to the California coast, or Mediterranean specimens carried to the waters of Florida, will not retain their original characters, but it does not follow that they will be inferior. It is even possible that with judicious selection localities may be found where the transplanted products may prove superior to their fellows at home, though it is true that one can hardly expect to improve on the quality of the fine sponges of the Mediterranean.

ECONOMIC APPLICATION OF THE METHOD.

ESSENTIAL CONSIDERATIONS.

The choice of a locality for commercial sponge culture is a highly important consideration. In the first place, it must be one that can be guarded, for whatever the law may be it can not enforce itself, as has been amply demonstrated by the history of the oyster industry and some of my own experience in sponge culture. For this reason the small planter will have to select his location near shore, where he can live and himself guard his property, and this practically restricts the choice for such persons to the region of the keys. The large planter, employing a number of persons, can afford to station a guard boat on his plantation, and can therefore carry on his operations farther from shore and on the high seas.

Selection also must be made of a locality not subject to the effects of freshets and heavy rainfall on the adjacent mainland, and for this reason the

vicinity of the mouths of rivers must be avoided. The water should at all times be of a saltness not much below that of the open sea, and no locality where it frequently falls below a specific gravity of 1.019 or 1.020, reduced to a standard temperature of 60° F., can be regarded as safe. Disastrous experience on the plantations of the Bureau and of Messrs. Cheyney and Bigelow at Anclote Key, where the density, especially near the surface, fell below 1.018 for a considerable period and killed the majority of the sponges, emphasizes this consideration. Along the keys below Lower Matecumbe or between the upper end of Key Largo and Cape Florida this trouble is not likely to be experienced, but there are few places near the mainland opposite the keys or in the Gulf of Mexico, where localities close to shore can be occupied without apprehension from this cause. Several years may intervene between successive periods of fresh water, and the fact that it does not occur for one or two years does not guarantee that a plantation will not experience its effects just when the planter is beginning to hope to reap the results of his labor. With this consideration firmly in view, there is no great difficulty in avoiding most of the disasters which have affected the experimental work.

The experiments with wires and lines for the suspension of the cuttings above the bottoms having not reached favorable termination, the use of soft muddy or densely grassy bottom can not be recommended, and the sponge grower is, therefore, practically restricted in his choice to such bottom as is more or less capable of supporting a natural growth of sponges. Disks and triangles tend to sink on mud marl or shifting sand, or are overgrown when deposited among dense marine vegetation, in any of which contingencies the cuttings are either killed or injured. Even when the sponge is but partially buried in sand the basal portion will die from suffocation, and the still living upper parts will eventually lose attachment and be carried away. But a sparse growth of grass may prove highly beneficial in stimulating a more rapid growth of the sponges. This appears to be indicated by very recent experiments, and if it should prove true a large area of virgin bottom will be opened to productiveness. Otherwise, the selection of a sponge farm is practically limited to rocky bottom, though there are occasional localities where a mud bottom comparatively free from vegetation is sufficiently firm to support disks or triangles.

Care must be exercised also to avoid places where there is much sand carried in suspension in the water, as this will be deposited in eddies created by the sponges and their supports, and will gradually build up around the plants. This difficulty can be avoided on otherwise suitable bottom by raising the cuttings on spindles, so as to allow the currents to have a scouring action below the growing sponges. For attachments it is recommended that the disks described in a previous section of this paper be employed. The plain disk perforated by two holes is the simplest and cheapest form of attachment, but its

use involves more labor than when the form with a short lead wire spindle is used. The cuttings should be bound to the disk by short pieces of no. 14 or no. 16 Brown & Sharp gauge aluminum wire, passed through the substance of the cutting, and thence through the holes in the disk, the ends twisted together below.

The cuttings should be made as already described, and should have preferably a volume of 8 to 10 cubic inches, measuring, say, 1½ by 2½ by 3, or a little less. They should be made as regular as is convenient without the expenditure of additional labor. They can be handled and exposed to the air without special precautions, but should not be allowed to remain in foul water.

If the disks with short spindles are used, the cuttings may be merely threaded on to the spindle by means of a needle, as has been already described, the cuttings being pushed down into contact with the cement disk, to which, as well as to the spindle, they soon grow fast. The process is much more rapid and less laborious than wiring the cuttings to the plain disks, which fact almost compensates for the increased cost of material.

The triangles are not recommended excepting when it is necessary to use long spindles to raise the sponges above possible sand deposit, in which event they are less liable than the disks to capsize under the impact of the waves against the larger sponges. They are more difficult to handle and transport than are the disks, and more easily broken. When fitted with 8-inch spindles of lead-covered iron ribbon, they cost about twice as much per sponge as do the disks, and the greater labor of transporting to any considerable distance will add to the difference in cost.

In shoal water the disks or triangles with the cuttings attached may be dropped overboard right side up. They will in the great majority of cases sink to an upright position on the bottom, though occasionally, in strong currents, one will capsize in its descent. Advantage should be taken of the first opportunity to inspect the planting, to right the capsized disks, and to shift any that may have fallen on those already planted. In deep water there is greater liability that the disks will capsize; the danger is less with triangles. Though the experiment has not been tried, it is probable that an inclined chute, one end resting on the bottom and the other coming to the side of the boat, down which the disks could slide, would not only insure an upright position of the disks, but would generally facilitate planting. As the boat was hauled ahead the disks would be distributed over the bottom in rows.

FINANCIAL ASPECTS.

The cost of planting will vary somewhat with the locality, but the following figures, based on actual experience at Anclote Key, are fairly representative of what may be regarded as average conditions. The computation is based on

the requirements for planting 1 acre with a sponge on each square yard of bottom.

For plain disks:	
4,840 disks, at 2 cents	$96.80
4,840 cuttings, at 2 cents	96.80
Labor, planting, fifteen days, at $2	30.00
	223.60
For disks with short lead spindles:	
4,840 disks, at 2½ cents	121.00
4,840 cuttings, at 2 cents	96.80
Labor, six days, at $2	12.00
	229.80

The first cost is slightly in favor of the plain disks, the expense for aluminum binding wire being so small as to be negligible, but when it is remembered that both kinds of disks are available for subsequent plantings when recovered, this advantage disappears. Assuming that during four years of growth 20 per cent of the original cuttings die and that the disks to which they were attached are lost on account of their inconspicuousness, each of the above accounts would have to be credited with the value of the disks recovered, 80 per cent, amounting to $77.44 in the first case and $96.80 in the second, making the actual cost of planting in the two cases $146.16 and $133, respectively.

In subsequent use of the disks for replanting, especially in deep water where a diver is employed, the advantage is strongly in favor of the disks with spindles for reasons that have been already explained. The cost of harvesting the sponges can not be stated, as there are no adequate data available. In shoal water, where the sponges could be taken by hooks and the replanting with fresh cuttings be carried on simultaneously, the cost would be slight. Where a diver would have to be employed the expense would be heavier, but by using the spindles this could also be reduced by planting fresh cuttings as fast as the mature sponges are taken, without removing the disks from the bottom. In most localities in deep water there would also be a compensatory greater return on account of the superior quality of the sponges.

Assuming that there is no expense in guarding the beds, but that this service is incidentally performed by the men making the disks and planting the sponges, the apparent profits to be derived from sponge planting are as follows:

Net cost of planting 1 acre with 4,840 cuttings	$133
Value of 3,872 sponges (80 per cent of 4,840), at 25 cents	968

Thus, at the end of four years from the date of planting, the net value of the sponges on the bottom would be $835, assuming that they had grown at the rate demonstrated at Anclote Key and had attained an average weight of 1¼ ounces, dry, that the mortality during their growth was 20 per cent, and that

the value of pure sponges is $4 per pound, which is less than the average of recent years. These assumptions are all regarded as very conservative.

From this must be deducted the cost of harvesting, which, in shallow water such as is to be found among the keys, should not exceed about $25 if proper conditions of weather and water be availed of. The net return, therefore, from an original investment of about $225 per acre would be an average of about $200 per year. In deeper water the cost of harvesting the crop would be somewhat greater, but as the operations would be carried on on a larger scale economies could be practiced which would reduce the expense.

In conclusion it should be plainly stated that the above calculation, though based on the actual results of experiment, is largely theoretical and that definite data can not be attained until the work is actually undertaken on a commercial scale. It is confidently believed, however, that if directions are followed in a suitable locality the actual net returns per acre will be considerably greater than those stated.

Plate LXIX

Fig. 1.—Sheepswool cutting of about the size recommended for planting.

Fig. 2.—Sheepswool sponge 11 months old, grown on wire at Anclote Key from a cutting about one-half size of figure 1. Natural size.

Key from a cutting about one-half size of figure 1.

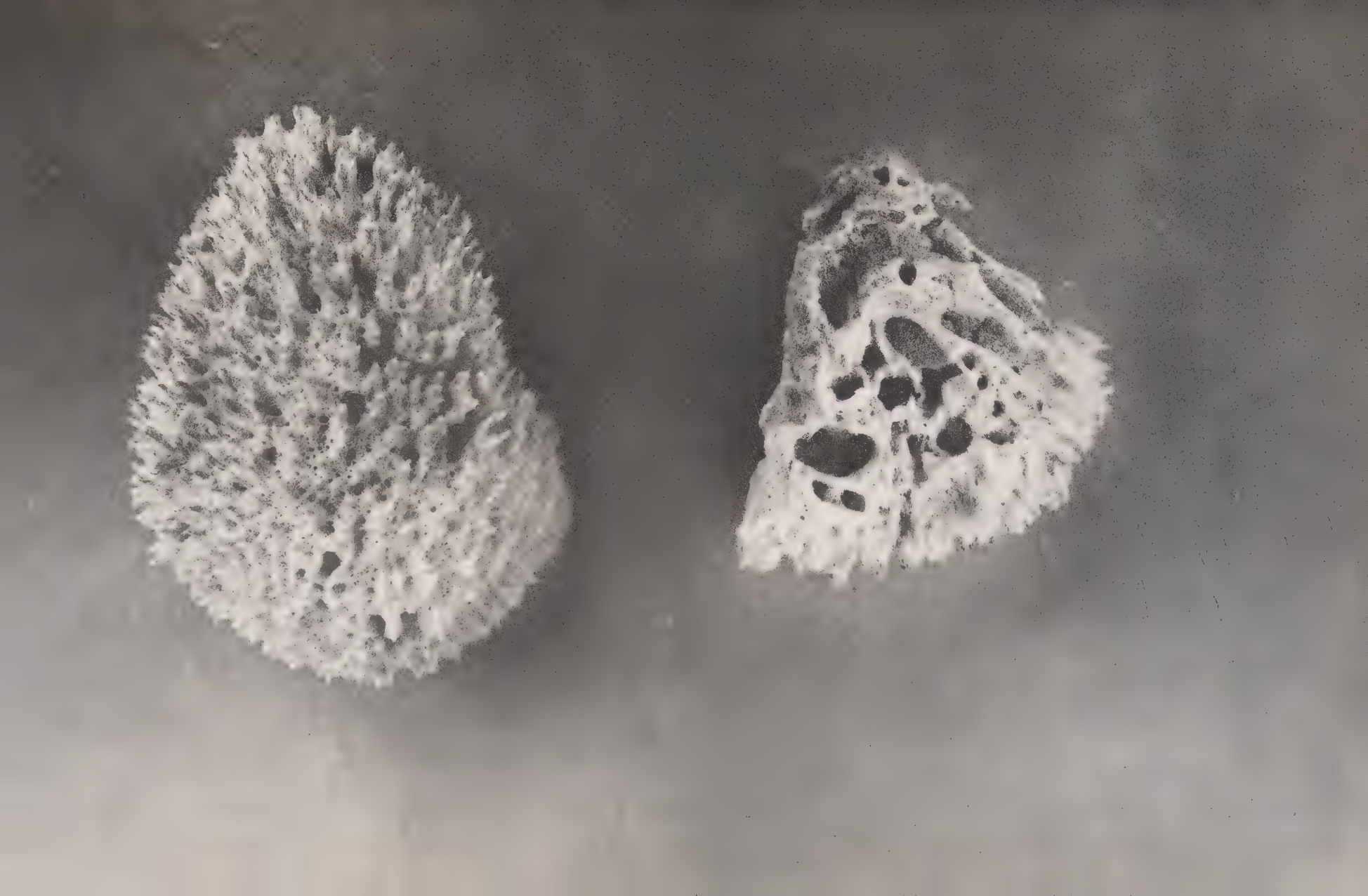

Plate LXX

Fig. 1.—Sheepswool sponge 20 months old, grown on wire at Anclote Key from a cutting about one-half the volume shown in figure 1, plate lxix.

Fig. 2.—Yellow sponge 21 months old, grown on wire at Sugar Loaf Key from a cutting about the size shown in figure 1, plate lxix. Natural size.

Plate LXX

Fig. 1.—Sheepswool sponge 20 months old, grown on wire at Anclote Key from a cutting about one-half the volume shown in figure 1, plate lxix.

Fig. 2.—Yellow sponge 21 months old, grown on wire at Sugar Loaf Key from a cutting about the size shown in figure 1, plate lxix.

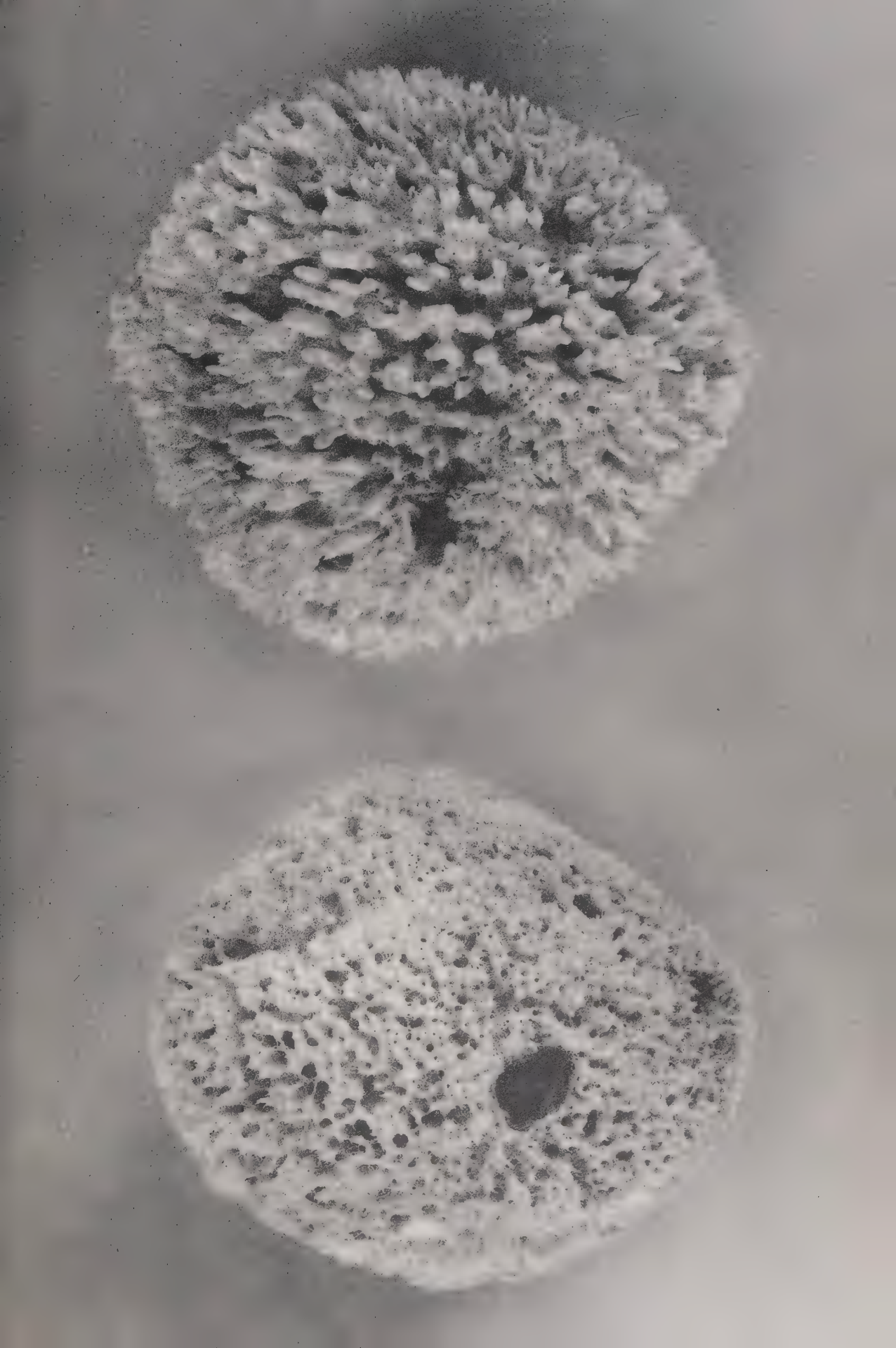

Plate LXXI

Sheepswool sponge 31 months old, grown on wire at Anclote Key from a cutting about one-half the volume shown in figure 1, plate lxix. Nine-tenths natural size.

Plate LXXI

Sheepswool sponge 31 months old, grown on wire at Anclote Key from a cutting about one-half the volume shown in figure 1, plate lxix. Nine-tenths natural size.

Plate LXXII

Sheepswool sponge 35 months old, grown on wire at Sugar Loaf Key from a cutting about the size shown in figure 1, plate lxix. Nine-tenths natural size.

Plate LXXII

Sheepswool sponge 35 months old, grown on wire at Sugar Loaf Key from a cutting about the size shown in figure 1, plate lxix. Nine-tenths natural size.

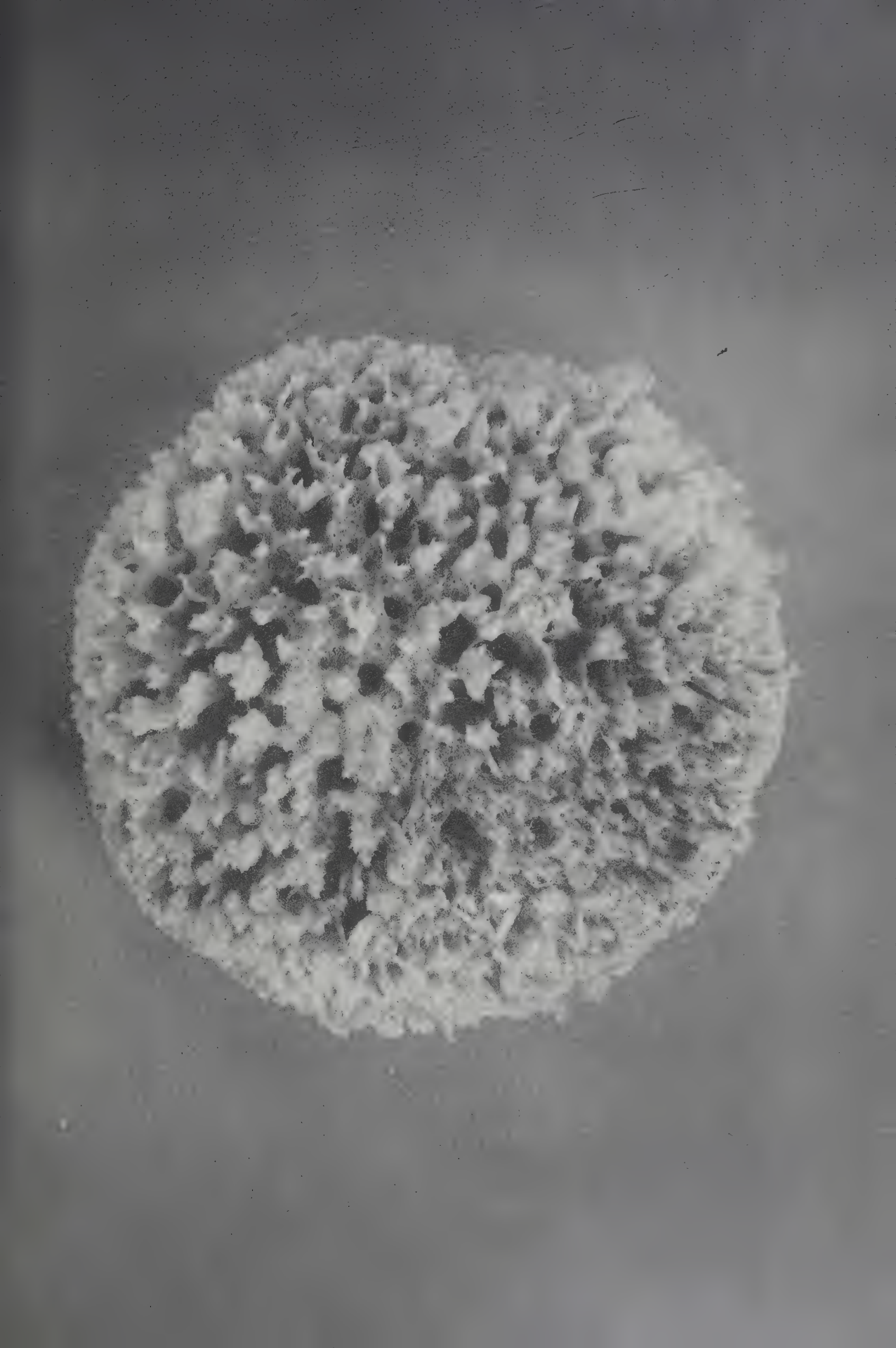

Plate LXXIII

Sheepswool sponge 52 months old, grown on wire at Cape Florida from a cutting about one-half the volume shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1 ⅓ ounces. Nine-tenths natural size.

Sheepswool sponge 52 months old, grown on wire at Cape Florida from a cutting about one-half the volume shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1 ½ ounces. Nine-tenths natural size.

Plate LXXIV

Sheepswool sponge 35 months old, grown on spindles (plate lxvii) in Cape Florida Channel from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1 ⅓ ounces. Nine-tenths natural size.

Plate LXXIV

Sheepswool sponge 35 months old, grown on spindles (plate lxvii) in Cape Florida Channel from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1½ ounces. Nine-tenths natural size.

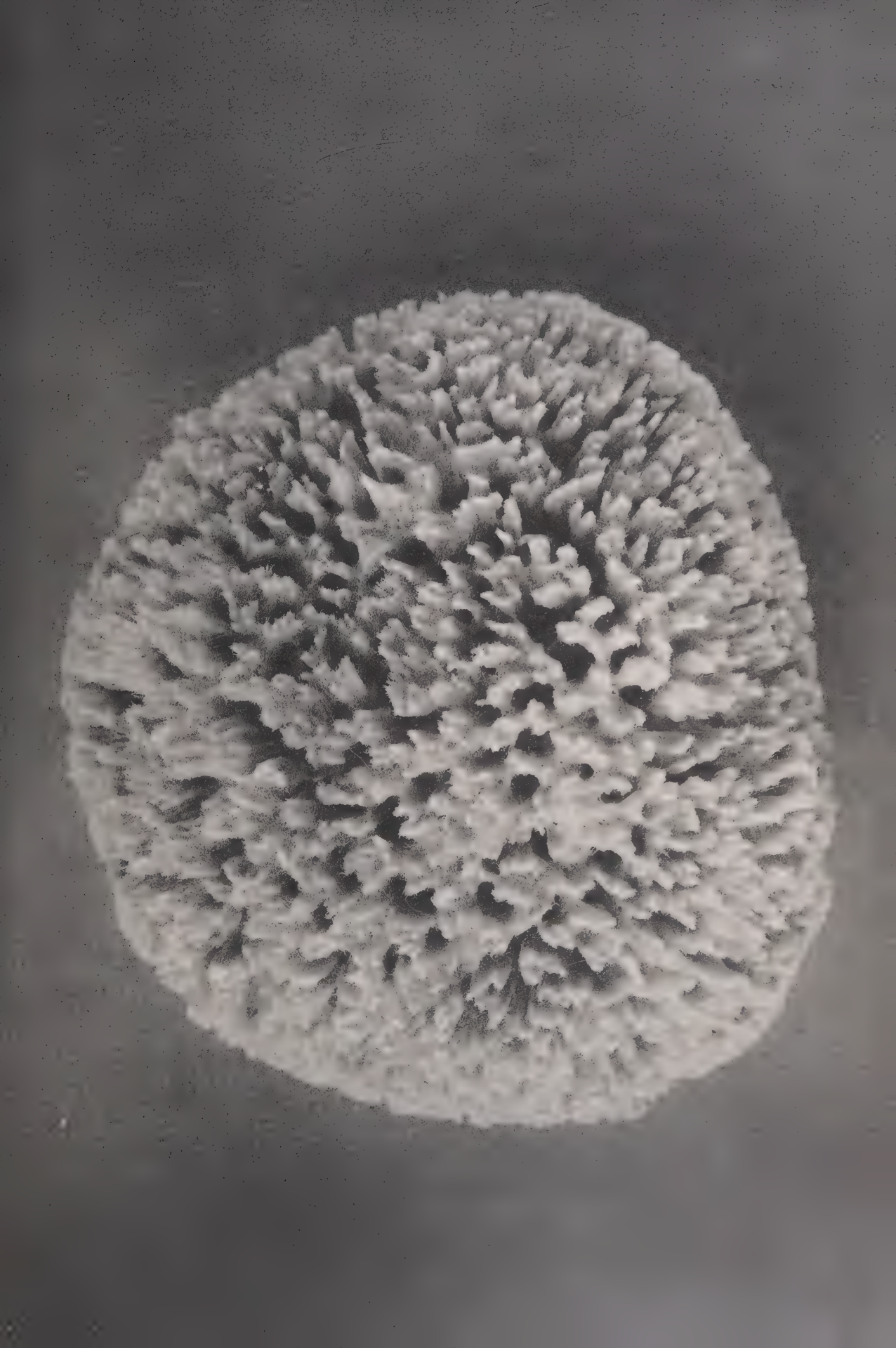

Plate LXXV

Sheepswool sponge not over 48 months old, grown on a cement disk at Anclote Key from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 2½ ounces. Nine-tenths natural size.

Plate LXIX

Sheepswool sponge not over 48 months old, grown on a cement disk at Anclote Key from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 2½ ounces. Nine-tenths natural size.

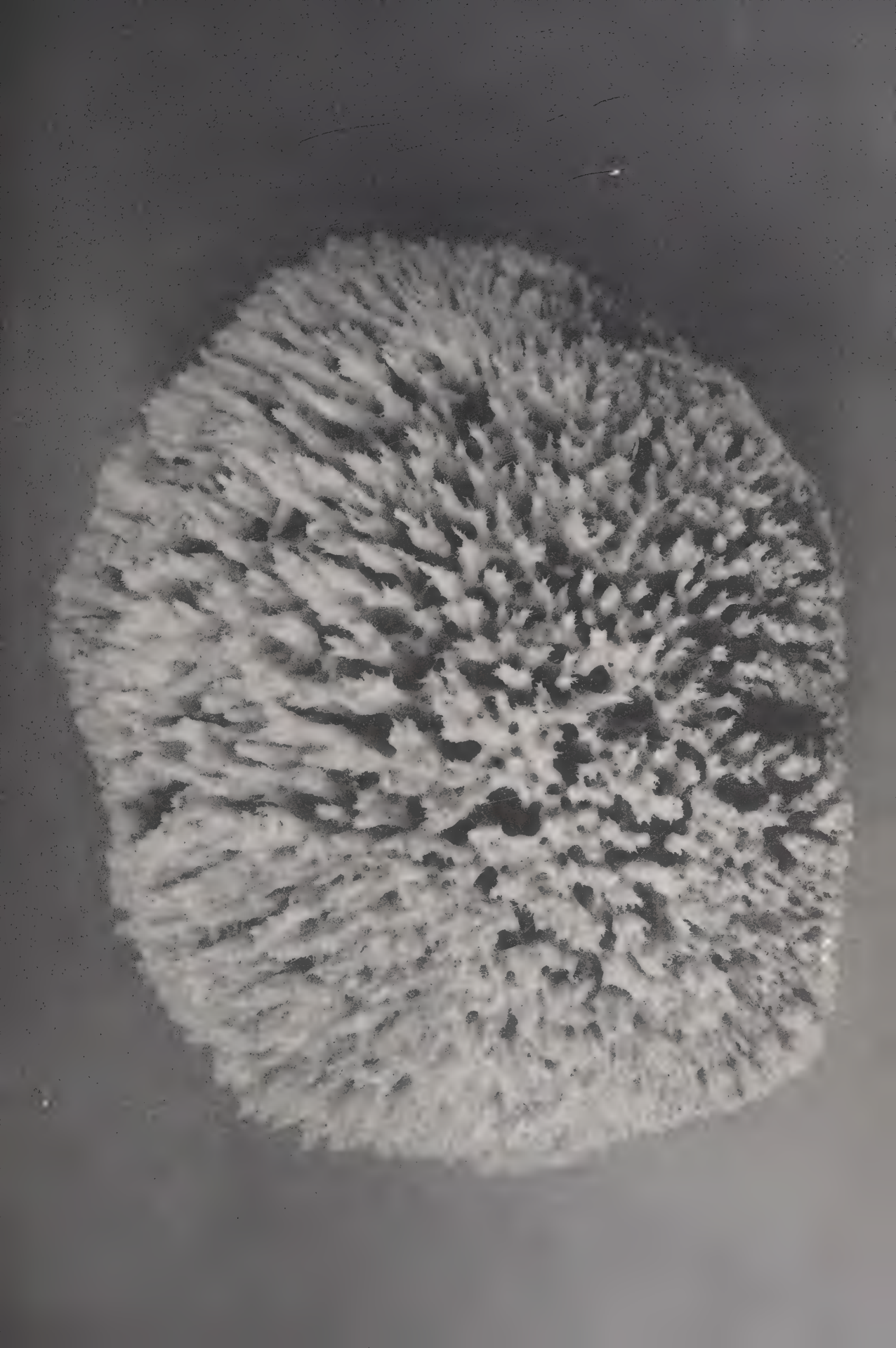

Plate LXXVI

Sheepswool sponge not over 48 months old, grown on a cement disk at Anclote Key from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1½ ounces. Nine-tenths natural size. This illustration shows the closely felted soft surface in contact with the disk. The corresponding surface of a natural sponge is open, like the interior, and therefore weaker and less durable.

Plate LXXVI

Sheepswool sponge not over 48 months old, grown on a cement disk at Ancolote Key from a cutting about the size shown in figure 1, plate lxix. Weight, dry and thoroughly cleaned, 1½ ounces. Nine-tenths natural size. This illustration shows the closely felted soft surface in contact with the disk. The corresponding surface of a natural sponge is open, like the interior, and therefore weaker and less durable.

SPONGE CULTURE

By Jules Cotte

Adjunct Professor at the School of Medicine and Pharmacy, Marseille, France

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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SPONGE CULTURE.

By JULES COTTE,
Adjunct Professor at the School of Medicine and Pharmacy, Marseille, France.

[Translated from the French.]

One of the greatest glories of the nineteenth century undoubtedly will be its patient, persevering, and methodical exploitation of nature's resources. It must be acknowledged, however, that not everything has as yet been obtained from the sea that may well be expected. Great progress may be looked for in the propagation of useful species inhabiting its depths, although in this field of work, by its excessive mobility, the limits of exploited areas must be determined in a very arbitrary way.

Great anxiety has prevailed for a long time among those interested in the sponge fishing and sponge trade because of the improvidence with which the sponge grounds were being worked. It has been the most productive methods of fishing that were being sought, without any thought of the morrow. It is important to combat these unfortunate tendencies, and several procedures, of which each has many partisans, have been presented: One is the regulation of the number of fishing appliances (for example, the limitation of the number of divers, as in Tunis); another, the complete prohibition of certain means (the prohibition of divers, as temporarily promulgated in Tunis and elsewhere); another, the fixing of a minimum size for the sponges taken; another, applying to the fishing of sponges the principle of regulated cutting, with alternation of rest and fishing for each of the banks visited by the fishermen; the temporary prohibition of fishing (several months a year) in order to allow the larvæ to leave the sponges and to take root; and, lastly, the propagation of sponges by methods of culture.

DEFINITION OF SPONGE CULTURE.

The term "sponge culture" must be understood in the widest sense possible. It comprises all the methods which man may adopt in order to obtain under his direct supervision or by his intervention an increase in the output of commercial sponges from any given locality. It would be sponge culture to carry sponges

from one locality to another, either to increase the number of individuals in an already sponge-bearing region, to improve their production, or to make a barren region yield. It would be sponge culture to take young sponges from a natural bed and transplant them to a given area of the sea, a parc, where they might acquire a good commercial size under the supervision of a caretaker. It would be sponge culture to gather sponge larvæ on appropriate collectors and rear them in a suitable place. It would be sponge culture to break a sponge in several pieces and develop separately the individual cuttings.

It is thus possible for us to conceive various methods of sponge culture, each of which merits individual study, for we feel more or less strongly the lack of knowledge concerning the physiology of the sponge species when we take up the different methods. We shall call the first method sponge culture by sowing, the second sponge culture by parcage, then sponge culture by means of collectors, and lastly sponge culture by cuttings.

GENERAL CONSIDERATIONS.

The first question to be considered, as it belongs to all the methods, concerns the choice of the locality in which sponge culture is to be attempted. As a general rule, it is necessary to provide surroundings identical with those in which sponges naturally live as regards the depth and the quality of the water. It is, consequently, unnecessary to insist on the fact that the salinity of the water must be similar to that in which the sponges prefer to propagate; for example, care should be taken not to repeat the error of Lamiral, who attempted to introduce sponges from the Levant into the brackish ponds of the Mediterranean Sea.

Delage said that the sponges of commerce require somewhat rough water, which keeps in suspension the grains of sand, the remnants of *Foraminifera*, and the spicules of sponges which accumulate in the primary fibers of their skeletons. This, however, is an exact theoretical consideration which may be entirely overlooked in practice. The entire volume of mineral débris which a toilet sponge keeps inclosed in its spongeous sheath is never very large; it does not exist near the coasts where sponge culture is possible; there are probably few localities far from the coast where the purity of water is so great that sponges might suffer from a want of material for the formation of their skeletons.

The authors reporting experiments in sponge culture almost all agree on one point, i. e., that the results of these experiments are always remarkable when made in waters where there exists a certain current. Buccich and O. Schmidt[a] advise localities but little exposed to waves coming in from the open sea, the bottom lined with highly colored algæ, and a certain current present.

[a] In Marenzeller.

Fogarty[a] has observed that the presence of a moderate current is most useful. These results are evidently explained by the simple fact, known to all, that the waters of a current are better aerated and contain a richer fauna. In such places, consequently, a more abundant supply of nourishment is available and from it the bottom animals, like the sponges, profit more or less directly. It may be easily understood that the presence of a certain current improves the conditions of the surroundings in which the sponges grow and facilitates thus the success of experiments in sponge culture. However, too swift currents should be avoided. The aim of sponge culture is the furnishing of skeletons of sponges easy to sell, hence we must not forget that the sponges grown in very agitated waters have a coarse skeleton and that this diminishes their commercial value. This observation was made a long time ago; Aristotle says that sponges differ according to their place of growth, "the ones by their softness and the others by their coarseness," and he thus explains this fact: "The softest sponges are those which come from deep, always quiet, waters." Similar observations have been made by modern fishers of sponges,[b] and the reason is easily found. We meet here one of the applications of the principle of Lamarck concerning adaptation to surroundings. The rôle of the spongeous skeleton of a *Euspongia* or a *Hippospongia* is to insure a relative rigidity to the body of the animal; it is quite natural that there should be established a certain automatic balance between the firmness of the skeleton and the shocks or pressure which the sponge has to bear. This is a hypothesis which Keller[c] has very well elucidated. It might not be quite wise to accept all the deductions he made from it, but the primary idea of his work seems to me perfectly correct. We can not as yet properly orient the phylogenic tree of the spongeous species. In certain kinds the spongeous matter is doubtless in part an ancestral persistence; in others it may have been acquired more recently, and we have no means of distinguishing between these two species. Hence, the ideas of Keller should not be discredited, because species generally inhabiting relatively deep and calm waters are provided with rather firm spongeous skeletons.

It would be interesting to know, also, without departing from this question, whether the individuals developed in agitated waters owe the firmness of their skeleton to a difference in the nature of their spongeous matter (greater impregnation of salts, for example, different physical condition, etc.) to a greater quantity of solid particles in their primary fibers, to a greater thickness of these fibers, or to a lesser flexibility of secondary fibers. We know that Len-

[a] In Rathbun.

[b] See observations of M. Crozat, made on the coasts of Provence, in: L'Industrie des pêches aux Colonies, by Darboux, Stephan, Cotte, and Van Gaver, p. 220, vol. I.

[c] Zeitschrift für die wissenschaftliche Zoologie, vol. LII, and Festschrift der Universität Zürich, Nägeli and Kölliker, 1890–91.

denfled has shown us the rôle played in the suppleness of sponges by the flexibility of their secondary fibers; it would be necessary to determine whether this flexibility is closely dependent upon the conditions of the surroundings and whether it is immediately modified by the latter, beginning with the first generation of cultivated sponges.

A detail which the cultivators of sponges must not lose sight of is the very great care with which the sponges should be manipulated. They thrive well only in running water, and the aquarium of a laboratory is not a favorable place for their development, unless the water be constantly renewed. Moreover, they very quickly die out of water, especially in summer. We do not find any commercial sponges in shallow areas not covered by water at low tide, which is a fact to be taken into account. Preference should be given, consequently, as far as possible, to methods of work in which the sponges shall not be taken out of their natural element, or in which they shall be taken out for the shortest period possible. We find in bibliography some information on the duration of sojourn in the air compatible with the submerged life and the normal development of individuals experimented with. Allemand has made numerous experiments on this point. He has found that sponges left ten hours in the shade (at 12° to 14° C.) may revive and continue to grow.

It might be said that, on the whole, experiments in the culture of sponges so far have not been conducted by the method which ought to characterize scientific work; they have been mostly empirical and lacking the substratum of knowledge which preliminary research and observations would have furnished. It seems hardly credible that the partisans for and against sponge culture should have spent so much time in discussion, debating whether sponges propagated from cuttings develop more or less rapidly than those derived from larvæ, without any research to ascertain the period of growth of a normal sponge. This is, nevertheless, the fundamental information, the key to all undertakings in sponge culture, which requires a fixed capital in order to withstand the fluctuations in market prices. If a sponge needs ten years to acquire an adequate size, or if ten months are sufficient for this, sponge culture has to be abandoned a priori, or deserves to be studied. Investigation as to the rapidity of growth of sponges derived from larvæ is the first thing to be done before sponge culture can be considered, and this research ought to be conducted methodically in each sponge-bearing country and for each of the species utilized. It is not possible to maintain that *Hippospongia equina elastica* develops in various countries with exactly equal rapidity, nor can it be said any more justly that the rate of its growth may be compared to that of the American sheepswool. Each variety may have its particular rate of development; we have already seen that in regions where there is a certain current the cuttings

of sponges grow more rapidly. It is consequently impossible to establish any general rule, and definite conclusions may be arrived at only after numerous observations. Yet, scientific observations in this line are not numerous and can not be superposed; infrequent endeavors have been made to throw some light on the legends current in this question.

We know nothing precise in regard to the most highly prized variety, *Euspongia officinalis mollissima*. Masse says that at Rhodes it reaches an average size within three to four years. As to *Hippospongia equina elastica*, Servonnet and Laffitte fix upon a few months, according to the statements of fishermen, as being the time necessary for this sponge to obtain commercial size in the Gulf of Gabesa. This idea continues to be applied to the Sfaxian region, where Servonnet and Laffitte have gleaned part of their information. The fishermen and the merchants of sponges determine the age of individuals (one, two, three years) by the dimensions. Bouchon-Brandely and Berthoule report that in the month of June a diver had observed carefully on a rock in the environs of Benghazi the existence of 57 very young sponges, lately out of their larval stage; the following year he dived at the same place and found the same sponges still alive, their number being almost the same, but their diameter about 10 centimeters. This observation deserves attention, as it has been confirmed by researches made by Allemand. This author has noticed that for *Hippospongia equina elastica* about two years, beginning with the time when the larvæ gets fixed, were required for the circumference to reach 30 to 40 centimeters.

The researches made in the laboratory of Sfax were more successful than those made by the Administration des Travaux Publics of Tunis. The latter had three pares constructed in March, 1897, at Sfax, at Kerkennah, and at Djerba, and sponges were carried there with all desirable precautions. The sponges had not increased in size by September, and they were invaded by algæ, which shows to what an extent their vitality had been weakened. Experiments were made with still less success, as may be easily understood, with sponges brought to Tunis in August, 1898, and held in glass jars. At Kerkennah eight living sponges were isolated under water by means of metallic gratings; development in size was noticed throughout the months of October, November, and December, but ceased later on.

The American species grow very rapidly, if we are to believe the accounts. The velvet acquires a commercial size in one year, and the sheepswool and the glove are said to grow faster still. Sawyer fixes[a] at ten months the time necessary for a sheepswool to weigh 45 grains. At Nassau the time is fixed at four months,

[a] In Brice.

and even three months[a] (Nye) is given for the same variety; for Arapian[b] this period varies according to localities, from four to six months. If this information is correct, which even Bidder doubts, it is easy to understand the optimism of the fishermen who do not fear any serious decrease of wealth of growth; it would seem, however, that if the impoverishment does not take place so rapidly in all sponge-bearing countries it yet threatens them all, for in none of the commercial species is development so extremely rapid as might be expected from some of the opinions I have mentioned here.

CULTURE OF SPONGES BY PLANTING.

It was by planting that the culture of sponges was first undertaken by Lamiral. Being one of the members of the Société d'Acclimatation, he prevailed upon the latter to intrust him with the mission of transplanting to the western coast of the Mediterranean Sea *Euspongia officinalis mollissima*, which inhabits the eastern region of this sea. The knowledge of Lamiral concerning the biology of sponges was elementary, and among the localities in which he proposed to introduce them were, as I have already mentioned, brackish ponds along the shores of the Mediterranean Sea. The Société d'Acclimatation had intrusted the study of the propositions of Lamiral to a commission, the reporter of which was Loubeiran. The report was very sensible and contained excellent advice as to the conduct of such work. The brackish ponds were to be abandoned, and advice was given in favor of localities along the shores of Africa. Lamiral had been given a sum of 5,000 francs, of which 1,000 francs were donated by the governor-general of Algeria, Marshal Pélissier.

Lamiral neglected one of the most important precautions indicated in the report of Loubeiran. Instead of keeping the boxes containing sponges submerged in the sea, he disposed them on the deck of the steamer. The water was changed, it is true. The period of transportation was likewise badly selected—in June the temperature is much too high. Attempts were made with ice to cool the water flowing on the sponges, but the effect of these adverse conditions did not fail to show. Tank water is alive with bacteria; Lamiral thinks that they are sexual products:

> The water flows out of the tanks, leaving on deck a fatty and white substance which must be the substance of the larvæ * * *. The difference in temperature of the water in the tanks has advanced the period of swarming of the sponges. They are ill from the parturition excited before its time.

Arrived on the coast of France the sponges were placed in cement boxes and deposited in the roadstead of Toulon, at Bandol, at Pomegues, and at Port-

[a] Cited by Thomas Lee in Report on the work of the U. S. Fish Commission steamer *Albatross*, by Z. L. Tanner. Report U. S. Commission of Fish and Fisheries, 1886 (1889).

[b] In Brice.

Cros. Those placed at the latter point had traveled a whole month; it may be easily understood in what condition they were. At the end of the same year, the sponges in the roadstead of Toulon were said to be still living and even to have increased in number (?). But at the close of the following year nothing remained of them anywhere. Such was the end of the enterprise. The transplantation of these 123 sponges from Syria cost 4,993.20 francs.

Lamiral later organized at Marseille a committee of aquiculture, which had only a few meetings and did not have the time to produce any useful work. The culture of sponges was on its program, but no attempt in this direction was made.

General Garibaldi[a] had thought at Caprera to make an experiment similar to that of Lamiral. In vain have I endeavored to obtain information as to whether Garibaldi's project was put into execution. It is more than probable that no attempt was made.

The projects of Espina, French consul at Sousse,[b] who wished to attempt dissemination of sponges on the coasts of Algeria, were not brought into effect, neither were those of Salse and Deel,[c] members of the Société d'Acclimatation of Nice, who proposed to transplant sponges from Syria to the shores of the island of Ste. Marguerite.

In 1896, at the request of the Colonial Office of Great Britain, Bidder indicated his opinion as to the mode of proceeding in experiments of this kind. He advised placing stones bearing the sponges in wooden cars with lateral apertures and having pointed extremities; these cars were to be towed in the rear of steamers, barely floating and letting the water flow through, which would be useful in case of an accident. But Bidder did not deem this experiment advisable; it would be "an experiment in the dark." He concurred in the opinion of Hyatt that the American sponges were simply varieties of the European species, produced under the action of a higher temperature and of coral sands; sponges introduced from the Mediterranean Sea to the Bahamas would probably undergo the same adaptations, and would thus become identical with the native varieties.

Lendenfeld does not admit, and not without reason, such plasticity in the sponge family, but he does not believe any more than Bidder in the success of attempts to transplant sponges long distances; he holds as a principle that transplanted sponges are less suited to their surroundings than the native ones and consequently not so well fitted for the struggle, a fact which will cause them to disappear in time. Expressed in such a form, this conclusion is some-

[a] Bulletin de la Société d'Acclimatation, vol. VIII, 1861.
[b] Ibid., vol. X, 1863.
[c] Ibid., 2d s., vol. I, 1864.

what too arbitrary. The density of the population of sponges on the banks is not so great that new individuals might not live in unoccupied spaces. It seems that the deterioration and degeneration of imported species is more to be feared than their entire disappearance, if the choice of the varieties and of the localities destined to receive them be made with sufficient care.

All this obviously pertains to transportation at long distances. There should be no hesitation whatever where short distances are concerned. All naturalists know that such transplantation is possible and, taken all in all, quite easy. All those who have attempted it have succeeded, no matter what species of the sponge family was experimented with, and experiments have several times been made with the commercial varieties. As to the *Hippospongia equina elastica*, Allemand transported in April and May, 1906, 67 sponges obtained at Sfax, which he immersed and made to live in the Lake of Tunis; on June 15 of the same year 44 remained alive, some of them, however, in a rather bad condition.

There is a reason for asking whether the culture of sponges from seed is worth the effort. It may answer two purposes—that of introducing sponges and establishing fishing grounds in regions naturally without this industry, or that of improving the production of a region having sponges of inferior quality by renewing the varieties existing there. Whatever the object in view, it is necessary to make the attempt with the greatest possible number of individuals and to be content to wait for results in a distant future. For the dissemination of the introduced varieties, we must depend upon the swarming of the larvæ around the centers of dispersion formed by the transplanted individuals, and it is only after a sufficiently long time that a group of these individuals may be seen to form an oily spot around the place where they were deposited. It is, consequently, an undertaking demanding much time and much money; we can not expect private persons to risk the undertaking for the purpose of profit; only powerful organizations can afford to take the initiative in this matter.

The rapidity with which the diffusion of the acclimated colony occurs depends upon a large number of factors. Account should be taken of the strength of the current at the given point to carry the larvæ along and, moreover, of the active movement of the larvæ themselves. We know very little concerning this latter question, however. I do not think that much has been learned as to the rapidity of movement of larvæ of the utilized species. I have, however, demonstrated that in the monaxid *Reniera simulans* the larvæ move at an average rapidity of 0.10 meter per minute. Under the combined action of the beatings of their lashes and the force of the current, the larvæ of sponges may make quite long distances, though these distances in actuality

seem to be rather limited. On the one hand, the movement of larvæ does not occur constantly in a clearly determined direction, but in a most irregular zigzag. On the other hand, the larvæ pass but a short time in a free condition, not over a few hours; hence they generally are fixed near their parent. Consequently the extension of transplanted colonies takes place very slowly. On the exploited points off the coast of Tunis observation showed that the maximum density of groups of sponges varies each year in a direction determined by the currents and the tide, but that the area of these displacements is not extensive.

If it is desired to sow sponges in an almost barren region or in a region situated a short distance from cultivable banks, it is necessary to ascertain that there are no special conditions adverse to a spontaneous growth on these bottoms which might interfere with the success of the proposed attempt. Let us take as an example the coast of Provence[a]: There may be found the *Hippospongia equina elastica* and the *Euspongia officinalis lamella*, but the individuals are not numerous in general, so few in fact that their presence was for a long time unperceived. Shall these be considered as the scarce descendants of former colonies which have disappeared almost entirely? It is certain that these sponges have a difficult struggle against unfavorable external conditions, and it would not be logical at the present stage of our knowledge to bring here at large expense the same varieties of sponges as the native ones in an attempt to disseminate them where sponges a long time acclimated show so little vitality.

Allemand noticed that the bottoms of the cantonment in the vicinity of the laboratory of Sfax are not everywhere favorable to the life of the sponges. In one part of the bottom "invaded by light yellow algæ, which probably harmed the sponges," all the individuals planted there perished. This is one more proof of what I assert, i. e., that the biological study of sponges is as yet not sufficiently advanced for the success of an undertaking in sponge culture to be determined in advance.

In short, sponge culture by seed may be compared to the replanting of forests on mountains by setting out a certain number of adult trees, the fate of the enterprise resting solely on the spontaneous dissemination of seeds from the latter. The results obtained might be excellent in some cases, while in others only failures would be registered. The seeds of the transplanted specimens might be inferior in the struggle for existence as compared to the neighboring specimens of vegetation; herds of cattle, if they were allowed, might destroy a quantity of young plants, and, similarly, the larvæ of sponges might in certain places be pursued by active enemies. Lastly, imagine the

[a] See J. Cotte: La pêche des éponges en Provence, Comptes rendus des Sociétés savantes de Provence. Marseille, 1906.

disappointment awaiting the sylviculturist who should attempt to grow chestnut trees on soil permeated with lime. Compared to our knowledge of sylviculture, our knowledge of sponge culture is most uncertain, and it is therefore difficult to foresee the future of sponge culture from seed. There arises in this instance the question of species; each individual case ought to be studied separately and only one general rule may here be given—that recommending the greatest prudence.

SPONGE CULTURE BY PARCAGE.

This method might give more immediate results than the former. Undertaken by a private individual in a limited and well-defined area of the sea, it would consist in preserving sponges of small dimensions, brought up in fishing, by placing them in favorable localities, whence they would be taken out at the desired time to be prepared and sold. The fisherman would not neglect the small specimens, the skeleton of which can be sold only at a loss. If the legislation of his country is wisely protective, if it forbids the fishing, sale, and exportation of small sponges, the fisherman will preserve them in parcs, awaiting the time when they will be sufficiently developed.

Such an enterprise is theoretically possible, but this does not mean that it would be remunerative. Sponges which it is desired to preserve must be gathered and transported with the greatest precautions, for which there are no facilities in practical fishing and which would render the latter quite expensive. In spite of the greatest care individual sponges would suffer fatally; the death of some would be unavoidable and the survival of the others would demand a certain period of time to recuperate and regain their former health before growing. "A fixed fragment, or an entire sponge transplanted and fixed like a fragment, will exhibit a rapidity of development much inferior to sponges coming up spontaneously." Such is the opinion of a convinced sponge culturist, Allemand.

The installation of a parc would probably be subjected to an annual tax which we might suppose to be quite negligible; but expenditures of maintenance would not be at all negligible. Sponges are a commodity which it is very easy to steal, and it would be necessary not only to supervise the parc but even to inclose it. It has been observed that sponges do not develop so rapidly when they are subjected to too much thinning. This was noticed by O. Schmidt and Buccich in regard to *Euspongia officinalis adriatica*, and it was likewise observed by Allemand in regard to *Hippospongia equina elastica*. Sponges can not, consequently, be kept in very shallow water; the inclosing of the parc would then be very expensive if it were done with a wall; it would be necessary to content one's self with determining the boundaries by means of floating beams.

However it might be effected, this expense would have to be added to that involved in taking up the sponges with which to stock the parcs. It remains to be seen whether these expenditures would be covered or exceeded by the profit from this enterprise.

Everything depends upon the rapidity of growth of the sponges. We have already noticed the data obtained. In Tunis, for example, we may expect from what we have learned that specimens of *Hippospongia equina elastica*, too small to be sold immediately, may be placed in parcs and would be ready for preparation beginning with the following year. Profit would be rapidly obtained from the difference in price for small sponges, which must be sold at a loss, and that of sponges of commercial size. It is difficult to calculate, however, whether this difference in price would counterbalance the expenditures involved. This is a question to be solved by experience alone. So far, we have the right to have a limited confidence in the future of this method of culture, but not to believe in its importance, since it seems that it can never be adopted on a very large scale.

SPONGE CULTURE BY MEANS OF COLLECTORS FOR LARVÆ.

This method, which might be considered as the most perfect theoretically, consists of parcage, not of the small sponges obtained by difficult and very expensive fishing, but very young sponges, fixed on adequate collectors. This method was neglected by most of the experimentors in spite of the advantages which it presents theoretically; this comes from the fact that the authors hesitated to undertake observations on larvæ of sponges, the average length of which is of about half a millimeter.

Ralph M. Monroe,[a] after having stated the results obtained by sponge culture by cuttings, says:

> It is quite possible that with state protection to the planters, and better methods to be determined upon by further experiments, sponge culture might be quite profitable. My belief is, gained in oyster culture from spawn, that a similar method with sponges will eventually prove the correct one, but until more is known of sponge biology it would be useless to suggest methods, notwithstanding the fact that several points in connection with it have been to my mind quite clearly demonstrated.[b]

In "L'Industrie des Pêches aux Colonies" we read:

> The desired aim might be more easily reached, perhaps, in operating on methods similar to oyster culture and clam culture, by receiving on suitable collectors the larvæ given out by sexually mature sponges in closed spaces. * * * It should not be forgotten, however, that it would be a very difficult attempt.

[a] H. V. Wilson has studied the reproduction of sponges "by means of eggs, by means of the gemmules, and by cuttings." (Report Commission of Fish and Fisheries 1889–91 (1893).) Wilson's works have been published, but he is not engaged in sponge culture.

[b] In Allen. 1896a.

Allemand announces practical experiments in this matter. The information published by him on this subject is, however, quite elementary:

> A larva, fixed to a support which we afterwards immersed in flowing water in May, 1905, has developed this summer, but gave in September only a large spot with an oscule, not a completely formed sponge; this fact ought to be ascribed to the manipulations necessary in the transportation of the larva.

Evidently we can not deduce anything from this solitary failure.

In view of the absence of positively established facts, we are forced to study this method in a purely theoretical manner. The choice of the collectors deserves first consideration. Breeding effected in aquaria shows that collectors of various kinds may be utilized for the larvæ of sponges, and we know that such is the case in nature, the larvæ of commercial species attaching themselves to plants (branches of *Posidonias*) as well as to shells and stones. It should not be forgotten, on the other hand, that these collectors must be easy to manipulate and very inexpensive. We need not expect such a number of sponges to attach to these collectors as might be observed on oyster collectors. Are there not found in Arcachon over 300 young ones on one tile? After the young sponges are attached they should be preserved, and we know that they must adhere to a support. If small stones or shells have been utilized as collectors this support will not be of a sufficient size to be considered permanent, and it will have, in its turn, to be attached to another support. Should tiles be used? Tiles would be durable, as there could be no question of disintegration, but the use of tiles would be expensive. It seems that a good collector might consist of wooden branches tied in fagots and immersed in the vicinity of sponges that have attained their sexual maturity. The branches possess great resistance to sea water, and by using them, as is being done in Italy in deep-water oyster culture, it would be possible to divide them and to tie them to ropes or to apparatus similar to that used for sponge culture by means of cuttings.

The use of fagots presents another advantage. It is generally admitted that the larvæ of sponges possess a marked negative phototropism. My observations, made on *Reniera simulans*, do not concur with those of other authors in this respect, and I found, on the whole, that the larvæ of this species are quite indifferent to light. Allemand has stated that the larvæ of a commercial species, *Hippospongia equina elastica*, seek a feeble light. It is certain that a negative tropism theoretically may be very useful to the species by impeding the larvæ from rising to the surface and by making them descend to less lighted regions, i. e., to the bottom, where they may find supports in great numbers; the opinion of a sponge diver would be quite useful, and it would be wise to ask him whether young sponges are not often attached above their mother to vertical walls of rocks. Should there really exist a negative phototropism the fagots would present the advantage of offering in their lower

region a zone of lesser light, where a greater number of larvæ would attach themselves; these would be attracted at this point less imperiously by the darkness of the bottom.

Supports for young sponges would be attached with advantage to bodies which the waves might put in motion—ropes treated so as to resist putrefaction, etc. Bidder luckily demonstrated the advantage derived by sponges living on mobile supports. Thanks to the renewing of food and aerated water, a consequence of their oscillations, the rapidity of growth of young sponges is increased. It should not be lost from view that in such cases the skeleton is coarser, as stated by several authors; the advantage gained on the one hand is decreased by the diminution in value of the product obtained.

The sponge cutting should be immersed at a certain depth, and it seems rational from this point of view to choose the depth preferred by the spontaneously grown sponges of the species it is desired to cultivate. Experimenters have noticed that sponge cuttings seem to fear too intense a light; this is a thing to be remembered and may find its application.

Sponge culture appears to us then as an operation fraught with difficulties, which can be attempted, without involving too high expenditure, only in localities offering an exceptional combination of favorable conditions. It should not be forgotten that if the sponges are to be immersed at a sufficient depth they must be attached so firmly that a wave shock can not detach them. They should also be protected against marauders, and the question of guarding the parcs and inclosing these arises again in connection with the expenditure involved.

It is possible to attempt the combination of this method of sponge culture with that undertaken in parcs by placing the collectors in the parcs themselves where the adult sponges are kept. There would thus be no interruption in the future gathering of sponges, since those maintained in the parcs would furnish the larvæ before being garnered, and the young sponges attached to the collectors would be taken care of until the time when, in their turn, they would emit larvæ and reach the necessary size.

It is to be regretted that this method has not been the object of serious study and has been neglected by the cultivators of sponges.[a] In the meanwhile we are reduced to simple hypotheses where it is concerned, and it is impossible to know whether it is indeed a practical method for purposes of profit. It might be possible that, at the present state of our knowledge, such an operation would not pay nor cover not only the expenditures involved by

[a] It will shortly be attempted along the French coast of the Mediterranean. I have been asked for information on this subject. Without concealing my skepticism from my interviewer, I told him that sponge culture by collectors alone or combined with parcage was the only method worth attempting.

the concession, the construction of parcs, the guarding mentioned above, but even the cost of manipulation of collectors and larvæ attached to these. Experience shows, in fact, that even on the richest of banks sponges grow at considerable distances the one from the other; this fact shows us that a great number of larvæ are lost to reproduction, as the sponges emit larvæ in considerable numbers, and if the majority of these came out victorious from their struggle for existence we might see among the sponges themselves intense vital competition. Such is not the case. Are the larvæ destroyed because only few of them find a favorable spot to which they may attach themselves; are few of them capable of living; or is their greater number the prey of their enemies? Let us study these three hypotheses separately.

In regard to the first, it must be observed that the larvæ possess very imperfect means for the seeking of a support; they have no organ of direction. When sponge larvæ are kept in a glass jar their fixing is retarded because glass is not a very suitable support; it is accelerated by placing in the jar solid objects to which the larvæ attach themselves readily, as fragments of shells, or even by covering the interior of the jar with a coating of collodion.[a] At the moment of the physiological crisis, which acts so radically on their anatomical structure, it seems that each larva which does not meet a solid body to which it might cling is destined to perish; it must attach itself or die. Do we not see at times, in our laboratories, sponge larvæ spread useless on the surface of the water of the jars against the upper layer as they would do against a solid body? If our hypothesis is well founded it seems to us that collectors with a large surface, disposed around the sponges, would save a great number of larvæ which in their normal course would not meet any bodies to which they could attach.

We know nothing at all of any of the enemies of the sponge larvæ. Among animals widely utilized by man the sponges are perhaps those the ethology of whose larvæ is least known. We know that adult sponges are respected, ordinarily, by almost all marine animals; I saw accidentally, in an aquarium, blennies attack *Suberites domuncula* and serranids come and bite the parts wounded by the blennies. But these are exceptional cases. The immunity may be due to the great amount of organic ammonia contained by the sponges. How far are their larvæ left unmolested by other animals? This we do not know at all. We see that on bottoms of geological structure and flora identical in appearance there are banks rich in sponges separated by zones almost completely barren. We have every reason to seek to know why the distribution of these sedentary animals is so unequal, and we must observe that the interrelations of animals have not been sufficiently studied from this point of view.

[a] I have made this observation quite frequently. This question of the nature of supports offered to the larvæ is of the greatest importance to sponge culture.

This is a question of the greatest importance; if we knew that some animal species were greedy for sponge larvæ the presence of these species at given points would be a warning against the choice of such localities for sponge culture. Such a series of experiments, easily conducted and absolutely necessary, should be made as a preliminary by those who wish to encourage capital to take an interest in sponge culture. I intend to publish in the near future the results of research of this character.

We are completely ignorant of the reasons why in nature the number of larvæ that survive transformation is so very greatly limited. It is probable that there is a frequent combination of the two reasons on which I have insisted and that a certain number of larvæ after having escaped the attacks of active enemies succumb later because they fail to find suitable support at the moment when the transformation must occur.

We are obliged to consider these questions and to revert to them insistently, for experiments in sponge culture by cuttings the results of which are known to us seem to discourage us entirely from attempting sponge culture by means of collectors. The authors who made them mention but very superficially the attachment of sponges derived from larvæ on their apparatus. It seems, however, that a maximum of favorable conditions was combined there. A considerable number of sponges was assembled at a given point constituting a kind of parc; the apparatus of sponge culture consisted of collectors, and yet these collectors gathered almost nothing. Shall it be assumed that the sponges held in the parcs to be divided into sections had scarcely ever any mature larvæ or larvæ capable of living? This might be possible, although somewhat strange. Do cuttings habitually fail to reach sexual maturity under cultivation? Such a conclusion would annihilate certain hopes of sponge culture which shall be mentioned later. Shall it be admitted that the larvæ were emitted and that they died in the parcs? This would be a very grave deduction for the future of sponge culture by means of collectors if we did not observe that sponge cultivators have generally made their experiments by immersing the cuttings at a very slight depth.

However this may be, it will be noticed that there remain many obscure points by the solution of which alone can we foresee the chances of success of sponge culture by means of collectors. We may appraise the amount of capital needed for a venture of this kind, but it is absolutely impossible to know how many sponges may be garnered and, consequently, to what extent the capital engaged might be remunerated. From a purely theoretical point of view, sponge culture by means of collectors seems to us the ideal method, as being the most rational of all; but, on the other hand, it is the one which possesses the least number of scientific data. It would be lack of conscience to advise at pres-

ent the owners of capital to take a rush into the unknown by embarking on a venture of this kind before patient investigations had thrown some scientific light on the principal obscure points.

SPONGE CULTURE BY MEANS OF CUTTINGS.

This is the only method of sponge culture on which we possess any precise information, as this is the only one which has been seriously experimented with. In early antiquity observations were made on the facility with which sponges could regenerate. Aristotle affirms that "when a sponge is torn off it may be regenerated from the fragment left and become complete." The fishermen of the Mediterranean Sea continue to believe this. Hennique says that four years are necessary for a torn-off sponge to regain a good size. Masse likewise believes that the root of torn-off sponges grows up again, and he supposes also that the skeleton of the new sponge is less fine than that which it succeeds. This latter opinion can not be accepted without being tested, for it seems that if it were true the commercial varieties of sponges would have degenerated long since.

The first really scientific observations on the regeneration of sponges are due to Cavolini. This author demonstrated that a sponge which was detached from its support could adhere to a new support and continue to grow. Vaillant remarked that after isolating the cortex and the central part of *Tethya lyncurium* these two regions were susceptible of reproducing a complete individual; he also succeeded in grafting, the one on the other, two individuals of the same species.

But O. Schmidt had already undertaken research in this line on *Euspongia officinalis adriatica*, the soft fine sponge of the Adriatic Sea. In "Die Spongien des Adriatischen Meeres" he announces his first attempts and complains of lack of capital. He was soon assisted as to the financial difficulty by the Deputation de la Bourse of Trieste; he met likewise in Buccich a valuable collaborator, thanks to whom he could continue at Socolizza, northeast of Lesina, a long series of experiments (1863–1872). The results obtained by Schmidt and Buccich were studied and commented upon in an excellent report by Marenzeller.

O. Schmidt and Buccich observed that the best season for operation was winter, as during this time it was possible to manipulate the sponges in the open air and thus cause a minimum of injury to them; they may be kept several hours in the open air in winter, whereas their exposure in summer would be fatal after a few minutes' time. It was possible to secure the survival and development of fragments of sponges that had remained eight hours in the shade in February with a temperature of 7° Réaumur. On the other hand, the growth of the cuttings is slower in winter.

The sponges should be gathered by experienced men by means of the drag net rather than the hook. As soon as they are taken they are rid of their impaired parts, then fastened by wooden pegs, and, kept in water, towed astern of a boat. They are cut by means of a very fine saw into fragments measuring 26 millimeters longitudinally, and care is taken that each of the fragments retain as much as possible of the ectotome. It was observed in the experiments made at Lesina that if the sea remained calm for twenty-four hours fragments placed directly on the rocks adhered and were susceptible of further development. In practice it would be better to attach these fragments to suitable supports. Attempts of this character with wooden or metal pegs in cavities dug in flat stones or on the walls of wooden boxes did not give any favorable results. The greatest difficulty presented by metal pegs comes from their oxidation. Moreover, these first attempts were greatly interfered with because the supports became covered with sand and ooze. It may likewise be that the too intense action of light impeded the growth of the cuttings.

The apparatus constructed by Buccich gave far better results. The fragments of sponges, 72 in number for each apparatus, were perforated with a trepanning instrument, then threaded on bamboo sticks between two parallel horizontal boards. The apparatus was weighted down with stones and could be raised for examination by means of a handle attached to the upper board. The fragments were thus disposed beyond all risk of being covered with ooze and without any impediment to the free circulation of water, while the upper board of the apparatus served as a screen against the rays of light. The silicate varnish of the bamboo also protected the sticks most effectually against the action of boring insects, but the latter entirely destroyed the boards in a number of installations.

The place chosen for these experiments was a bay in which a certain current was felt, but which was well sheltered against the waves, and where the algæ at the bottom were highly colored. The operation may be considered as having succeeded when at the end of three to four weeks it is possible to ascertain that the cuttings have adhered to their supports. Beginning from this moment the growth is quite rapid; the cuttings reach a double or treble size during the first year; the growth is more marked during the first and fourth (?) years than during the second and third. This result can but surprise, and it seems to show that the observations were made on a limited number of cuttings for the whole, and that the influence of some untoward accidents has falsified the results. But however this may be, the cuttings had reached quite a considerable size at the end of five years, and the experimenters were able to conclude that a commercial size could be attained within seven years, showing the method to be a practical one.

A certain number of cuttings die, while others continue to live indefinitely without increasing in size; the materials of attachment deteriorate; but Schmidt and Buccich admit that in the hands of a careful operator not more than 10 per cent of loss need be expected. Applying these results, we see that 5,000 cuttings, the cost of which is 735 francs, would give at the end of seven years 4,500 sponges, valued at 2,205 francs, and thus an average increase in value of 210 francs. In a regular enterprise in which 5,000 cuttings were put out every year a lump sum of 5,880 francs would have been expended at the end of seven years, and from this on a profit of 1,470 francs would be obtained annually. Marenzeller deems the estimate of the price of sponges exaggerated, observing that the sale of such planted sponges would be difficult on account of the central perforation left by the bamboo sticks. The valuation would be correct if each sponge weighed 25 grams and could be sold at 20 francs per kilogram.

In the Bulletin de la Société d'Acclimatation (1879, p. 372) it is said that Schmidt and Buccich advise not to allow the cuttings to reach the current size; the cuttings might be allowed to develop only for three years, at the end of which period sponges would be gathered at a smaller size but would be sold at 0.10 franc. Four thousand sponges would cost 225 francs, including the interest of the capital for three years (which would be far from the valuation given above); the sale price being 400 francs (without deduction of the 10 per cent), we would have a profit of 175 francs. We must observe that the sale price of small sponges might fall below 0.10 franc if sponge culture, understood as above, became a current practice and flooded the market with small sponges.

In spite of the optimism of O. Schmidt and Buccich, they were obliged to interrupt their work. The Dalmatian fishermen crossed themselves as in the presence of a miracle when they saw the cuttings growing on the devices of sponge culture; later on, becoming more bold, they continually disturbed the apparatus with their nets and more than once they even stole it. In short, these classical researches had to be abandoned entirely on account of lack of protection against the fishermen.

Fogarty, agent of the firm of MacKesson & Robbins, has made similar experiments at Key West. The localities where the sponges were placed were not very happily chosen and the growth of the cuttings was not as rapid at it might have been. The cuttings of sheepswool were about 2½ inches thick; they were maintained at the bottom under about 2½ feet of water by means of wire or sticks put through them. Four months were required by the sponges to complete the healing of their wounds, and they did not grow during this time. One cutting was placed in a creek where there was no current, or very little, and its growth was very slow; the others developed very rapidly, and four months after they had been placed they had grown to four and six times their size. A total

of 216 specimens were planted; lack of protection against the fishermen here obliged Fogarty also to abandon his attempts. The result of his observations, however, was found sufficiently conclusive for Rathbun to demand that special laws be promulgated by Florida for the protection of future undertakings in sponge culture.

In 1896 there appeared a report by Allen, director of the Laboratory of Plymouth. This report was made at the request of the colonial office of Great Britain with the desire of introducing sponge culture in the Bahamas. We find in this report, in addition to accounts of the experiments of Schmidt and Buccich, and of Fogarty, information, though not detailed, on experiments made in Florida by Benedict. The latter divided the sponges under water; he wanted simply to prove that cuttings attached to favorable localities grew rapidly. The fishermen were greatly opposed to these experiments, fearing that they might be conducive to the creation of monopolies which would deprive them of their means of livelihood.

In 1889–90 Ralph Monroe likewise experimented in Biscayne Bay at a point where the most varied conditions existed. He used for supports trunks of white wood, about 12 feet in length, provided with a cross-piece at one end so as to hinder them from rolling. The cuttings were affixed to these in various manner; the method most quickly executed, but far from the best, consisted in making use of small pieces of double copper wire which were pushed into the wood by means of a special instrument. Galvanized iron can not be used in any form whatever, as it corrodes too rapidly; brass wire must likewise be eliminated on account of the deleterious action on the sponges of the salts formed by the chemical action induced. The sponges with which Monroe operated, solely sheepswool, readily endure being in the open air for several hours, though they die very quickly in stagnant water. They were cut on a cutting board with a very thin and sharp knife, the pieces being about 1 inch in length. Each whole sponge gave an average of 25 cuttings. The cuttings were immersed to depths varying from 8 feet to less than 1 foot at a distance of 12 inches apart. It would be easy to plant, with the aid of two assistants and a good boat, from 600 to 800 cuttings per day. The sponges, with a few exceptions, survived the operation and began to grow well. Later, they were destroyed or lost in various ways; nevertheless a lot, planted at Elliott's Key under 4 feet of water, gave at the end of six months 75 per cent of living cuttings which had doubled their size. In some of the other lots individual sponges were brought to maturity, but the average loss was considerable on account of insufficient adherence to the supports, or from other causes. The author concludes by saying that satisfactory means of attaching the cuttings is still to be found; the localities selected should be in bays and lagoons sheltered from the high sea, the too rapid currents, and too agitated

water; the cuttings should be immersed at a moderate depth in order that it may be easy to manipulate and observe them. The growth is more rapid when the current is strong, but the shape is then more frequently bad and the skeleton hard. This point, however, is not quite elucidated by the author. Under favorable conditions the cuttings double their size in six months, consequently eighteen months to two years would suffice to produce a sponge of commercial size. "It is quite possible that with state protection to the planters and better methods to be determined upon by further experiment, sponge culture might be profitable." Nevertheless, the author comes finally to the conclusion, mentioned above, that the most rational method in his opinion is the one closest to oyster culture. Let us observe that the estimates of Monroe as to the time necessary for a sponge to attain a commercial size are based on the results of one single experiment which was especially lucky and extended over only six months.

At the request of sponge merchants of Sfax, the Direction Générale des Travaux Publics (of Tunis) undertook researches on the biology of commercial sponges, and erected for this purpose a laboratory on piles in the open in the harbor of Sfax. This laboratory was intrusted to the supervision of Raphael Dubois. Allemand was appointed assistant director and made a series of experiments in sponge culture by cuttings, which he continued for two years and the results of which he published in 1906. He tells us that the sponges to be divided should be gathered with great care and utilized as quickly as possible after being taken, or they should be allowed to heal entirely in running water before cutting them up. He divided them with a very sharp blade previously immersed in boiling water for each cutting. The operation is successful when it takes place at a temperature of about 15°. If made at this temperature the healing of the cuttings rarely took more than three months, while in winter it is very slow, as is also the growth of the cuttings in this season.[a] On the other hand, the vivid light was, as in the experiments of Schmidt, detrimental to the healing as well as to the development of the cuttings. It is, consequently, of great advantage to shelter them.

In some ten months the cuttings grow to three times their original size. "In proportion to the growth observed, a fragment can form a sponge of commercial size (0.30 meter in circumference) only in four or five years." In short, the *Hippospongia equina elastica* developed somewhat more rapidly than the *Euspongia officinalis adriatica* of Schmidt. The author remarks that the apparatus of sponge culture must be very resistant and especially well sheltered. It is necessary to discontinue wooden materials, which suffered from the boring in-

[a] This concurs entirely with the results obtained by Schmidt and Buccich. The healing and growth of the cuttings is more rapid when they are not kept at the bottom of the water. Bidder, as we have seen, called attention to this fact.

sects, as did those of Lesina, and select "durable bodies of clay (pyramids, cones, or perforated amphoras)" or reenforced cement. Allemand forgets, however, to tell us how these clay attachments may be sheltered from light, for all the experimenters will not have the advantage of suspending their apparatus under a laboratory, as was done in Sfax. The author advised, a few pages earlier, the use of baskets or boxes to preserve the sponges precisely for the purpose of shielding them from too strong a light.

Allemand, agreeing on this subject with his predecessors, concludes from these researches that sponge culture has a real industrial and commercial value. But what he published, no more than what was published by the others, is of a nature to lead to this conviction. There is a great distance between laboratory experiments and the founding of an industrial enterprise. It should not be forgotten that the experimenters unconsciously pass very lightly over their failures and insist only on the encouraging facts, forgetting that industry must take everything in account, success as well as failure. Schmidt and Buccich discount 10 per cent of loss for undertakings in sponge culture; nevertheless, during the course of researches made by them during ten years they were unable to follow their most promising cultures for a longer period than five years; after this they became discouraged. In their hands, skillful by long practice, the final loss came near to 100 per cent. Monroe admits that the average loss in his researches was quite considerable. Allemand, evidently alluding to his own experiments, says that an undertaking in sponge culture, if well conducted, will suffer but a very small loss. We must, unfortunately, ask how he computed the mortality of his cuttings. It seems that he took into account only the mortality which occurred during the first weeks after the cutting of the sponges. We find information like the following in his table of experiments:

> Mortality, 7 per cent; at the end of February there remained two sponges. Mortality, 5 per cent; at the end of February almost all the fragments were dead. Mortality, 20 per cent; on June 29, 1906, the apparatus was entirely dislodged.

On the whole, the mortality in the work at Sfax seems to have been quite considerable; it must also be remembered that the experiments were carried on during a maximum period of two or three years, and it is impossible for us to foresee what supplementary losses might have taken place during the two or three years that would have to elapse before the sponges could have been garnered. This is information which a merchant ought necessarily to have.

With the exception of Schmidt, the sponge cultivators do not give the cost of their cuttings. "The cost of the installation will not be high," says Allemand. On the contrary, the cost would be considerable. Shall I repeat what I have already said about the other methods of sponge culture? The

fishing of sponges destined to be divided into cuttings must be effected with greatest care, thus the cost of fishing would be considerably greater than that of sponges destined for the trade. The transportation, the care of the sponges, the division into cuttings, the purchase and manipulation of the apparatus of sponge culture will involve supplementary expenditures, as will also the installation and the concession of the parc where the plants are to be made. It should not be forgotten that this parc must be established in deep water as far as this is possible, so that the cuttings shall not be kept too close to the surface, where the light would be too intense for them. It is necessary to inclose this parc and to guard it carefully; it was the theft of apparatus and in general the lack of protection which forced Schmidt, Fogarty, and Benedict to abandon their researches, and it would have been the same with the experiments at Sfax if the Direction des Travaux Publics of Tunis had not provided most efficient guard. A private individual could not count on so vigilant an assistance as that of the fishing guards and the custodian of the laboratory of Sfax, and would himself have to insure, in a permanent manner, both day and night, the guarding of his installations. Schmidt and Buccich seem to have neglected these various factors of expense in sponge culture in the estimate of the cost of their cuttings. The other sponge cultivators keep silent on this subject as if it were a secondary one. This may be so from a scientific point of view, but from an industrial one it is of vital importance.

In spite of all that has been published on this subject, it is as yet impossible for us to foresee at the present time what is to be gained from an undertaking in sponge culture. It is even to be admitted that the result of the enterprise would be a considerable loss. I do not mean Buccich's diminution of value of the sponges on account of the central perforation left by the bamboo stick; these are small details easily corrected by improvements in technique. We must notice that the time needed for healing was always considerable for the species with which experiments were made. This loss of time is not a negligible quantity. Moreover, the growth of the cuttings is slow. Allemand says that they would have to grow four to five years to attain the size reached in two years by sponges coming from larvæ. It is, consequently, not possible to see how the products of sponges, obtained at a great cost and bred at a great cost likewise, can compete economically with the sponges at present brought to market. As long as sponge banks are sufficiently supplied to permit normal fishing, until the value of sponge skeletons has increased considerably, it will be impossible to adopt any other conclusion than the one here expressed.

Such could be the case, however, if the yearly increase in size of the cuttings were far in excess of the size that would have been attained by the original sponge had it not been divided. Schmidt thinks that this is so, without, however,

having verified this statement. Allemand is far more convinced, for he has observed that "the whole of the cuttings taken from a small sponge gave a greater volume than that obtained from an identical sponge placed whole at the same time and under the same conditions." It is rather difficult to have this statement agree with another of the same author, i. e., "the growth of a fragment or of a sponge derived from a fragment is much slower than that of a sponge growing spontaneously and not coming from a fragment." We might conclude, perhaps, that the sponge "placed under the same conditions," the term of the comparison, had not a normal subsequent development. An accident in experimentation can not serve as a basis for generalization. It is, moreover, to be regretted that the most of the authors who have given us information on the culture of sponges do not give any precise definition of what they mean by size and volume; it seems to me that what they mean by doubling or trebling the size is the diameter, and not the size or volume.

Marenzeller, taking into consideration the results reported by Schmidt and Buccich, seemed to be skeptical as to the future of sponge culture. He finally raised the question whether this method of culture ought not to be applied only to the cutting up of flat and worthless sponges, the pieces of which would give sponges of rounded shape, or to the grafting together of badly shaped and consequently cheap sponges. Such application would be of very small importance. The fishermen garner sponges haphazard, without taking pains to give the care and minute precautions demanded for the manipulation of individuals destined for cuttings. When the sponge brought up by the harpoon is of little worth it is not reasonable to expect the fisherman to lose time in manipulating and preserving this worthless piece, which might be utilized in a more advantageous manner if he continued his fishing. Supposing that the fisherman followed scrupulously the directions given him, the worthless sponges thus gathered would cost the breeder of sponges much more than the sponges to be had on the market. He would then have to continue with them a series of procedures involving expenditures the history of which has been given here. And all this to bring about what results? To obtain at the end of several years sponges which also might be worthless, fit only to be thrown aside, like their parent.

The project of fusing badly shaped sponges into one does not deserve to be considered. It is only a pastime for the naturalist, not a procedure for daily practice, and only the virtuosi of sponge culture might attempt it with some hope of a modest remuneration for their day's work. But we have not yet gone so far, and there is no dean in sponge culture. Moreover, there is nothing to prove that the final result of these operations would always be perfect. Should I judge by what I obtained from attempts of grafting halves of different

individuals of *Tethya lyncurium*, ultimate disappointment may be frequently met, arising after premature cicatrizations.

Buccich questioned, on the other hand, whether no senile degeneration took place on cuttings obtained from senile sponges; the growth of these would be slower than that of a sponge of the same dimensions but developed spontaneously. This last proposition was entirely confirmed by facts, as we have already seen; but it should not be deduced thence that the opinion of Bidder on the senility of sponges has been verified. It is impossible to compare experiments made on intact sponges with cuttings attached to apparatus. Let us observe, however, as an accessory consideration, that Allemand thinks to have observed that cuttings taken from large sponges do not develop as well as those from small-sized sponges; but his information on this subject is quite meager. As far as the senility of sponges is concerned, our knowledge, I believe, is limited as yet to some measurements which Allemand made at Sfax. He noticed that in some fifteen months the circumference of certain sponges increased from 40 to 45 centimeters and of others from 50 to 54 centimeters, while some increased from 60 to 63 centimeters, which means an increase in volume of 455 cubic centimeters in the first case, of 544 in the second, and 580 in the third. It can not be said that these observations constitute a definite demonstration of the fact that the sponges had their vitality weakened as they advanced in age.

These are questions, moreover, the importance of which is purely theoretical, since sponge culture by cuttings can not be the subject of practical application. The methodical study which I have given here leads us inevitably to the conclusion which sponge culturists themselves were obliged to accept. We see that Monroe says doubtfully: "It is quite possible that * * * sponge culture might be profitable;" yet, after all, he thinks that the most rational method is sponge culture by means of collectors. The last experimenter who took up this question could not answer against the argument arising from these observations. After having said that sponge culture by cuttings possesses real industrial value, which I expressly deny, he ends, nevertheless, by preferring to it a mixed method in which, unfortunately, he has no personal experience. He considers as being "the true method of culture in the future" a combination of sponge culture by cuttings and sponge culture by planting; the cuttings would produce larvæ which would stock the parc. There would thus be every four or five years a harvest from the cuttings which had grown and every two years another from the sponges spawned in the parc. This mode of operating does not seem at all justified. It is difficult to understand why the author does not advise sponge culture by means of collectors as previously studied; why he insists upon utilizing, in spite of everything, the method proposed by Schmidt. Since the cuttings require five years to reach the size which the sponges reach normally in two years, it is very probable that the emission of

larvæ would be retarded or diminished in such individuals in similar proportion. It would then be quite illogical to use sponge cuttings even for this purpose. What opinion should we have of a horse breeder who would use only sick, crippled, or deformed stallions with which to increase his stock?

From whatever standpoint it be considered, sponge culture by cuttings seems to us only a scientific amusement which can not have any practical application.

CONCLUSION.

We see from the preceding that experiments in sponge culture so far made forbid all hope of ever seeing in current practice methods like the above, and command us most imperiously to warn those desiring to undertake this industry against imprudent advice which they might receive on this subject. There remain, however, other methods which have not been attempted or which were not tried seriously enough and on which our opinion must remain provisionally pending. Let us wait before expressing it definitely; let us await carefully conducted experiments to enlighten us. It would be unfortunate for the fame of applied natural science if industrial attempts at sponge culture, after having been lauded by naturalists, brought about failure from a financial point of view or ended in insignificant results, as when the mountain gave birth to a mouse.

Thorough consideration ought to be given to the matter before engaging capital in an enterprise that might be dangerous. Since the gradual exhaustion of the banks threatens all sponge-bearing countries, however, those interested in this question should be reminded that more important and more easily solved problems urgently claim their attention. There should be as uniform legislation as possible, promulgated after international agreement, regulating in various countries (1) the period for sponge fishing, so as to allow the swarming of the mature larvæ; (2) the minimum size of individual sponges fished and offered for sale; (3) the fishing apparatus, either in regard to character or number; and (4) the security of banks situated in neutral waters.

This is the first programme to be considered. When this is done, let us hope that precise researches during the interval shall have carried the question of sponge culture a few steps further, and that we shall have then a new basis for appreciation in thorough knowledge.

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EXPERIMENTS IN THE ARTIFICIAL PROPAGATION OF FRESH-WATER MUSSELS

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Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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OBJECT AND SCOPE OF THE UNDERTAKING.

The threatened extinction in the Mississippi River and its more important tributaries of those species of mussels whose shells have been taken in enormous numbers during the past fifteen years for the manufacture of pearl buttons has led the United States Bureau of Fisheries to undertake an extensive investigation to determine the possibility of artificial propagation of these mollusks, and to devise such means as may be practicable for restocking depleted waters which present favorable conditions. The general direction of the investigation has been placed in the hands of the writers, who for the past three years have devoted to the work as much time as their professional duties would allow. In certain phases of the work, however, many others have collaborated.

It was recognized at the outset that if the investigation was to have real practical value it would have to be wide in scope and extend over a period of at least several years. At that time little was known with accuracy of the breeding habits and seasons of the commercial species, of the biological and physical conditions under which they live, of their distribution, and of many other essential matters, while it yet remained to be discovered whether artificial propagation could be successfully accomplished. At the very inception of the work, therefore, a comprehensive plan was outlined which was designed to include every subject that might bear even remotely upon the central problem, and, although many parts of this programme have not yet been touched, much progress has been made in some of the more important lines.

The plan of work contemplated, besides a thorough investigation of artificial propagation, a detailed study of the life history and ecology of the Unionidæ, emphasizing especially the geographical distribution of the group throughout the Mississippi Valley, the breeding habits and seasons, the physical conditions of the waters in which the different species thrive, food, enemies, and diseases,

rate of growth, post-embryonic development, and the mutual behavior of glochidia, or larvæ, and fishes as parasites and hosts.

The results that have already been obtained, although far from being complete, will serve as a basis for future investigations, while the lines of attack in the main problems have been definitely indicated. We have proceeded far enough to make it clear that the ultimate end of the investigation is assured, and with proper facilities for the infection and care of large numbers of fish the final success of the work is no longer in doubt. The essential facts in the life history of the Unionidæ are known; the general conditions of infection have been determined; the entire feasibility of artificially infecting large numbers of fish has been established; while the requisite conditions for placing artificial propagation on a practical basis are clearly understood. Furthermore, during the summers of 1907 and 1908 several parties, working under the direction of the Bureau of Fisheries, have made extensive observations on a number of different rivers in the upper Mississippi Valley, with a view to determining the distribution of all of the species of mussels occurring in these waters. The rivers that have been explored in this manner are the upper Mississippi, Illinois, Iowa, Minnesota, Wabash, Ohio, and Tippecanoe, as well as several smaller streams in Indiana. When the results obtained by these parties have been brought together, we should be in possession of detailed information regarding the distribution and relative abundance of at least all of the important commercial species throughout this region. In addition, the breeding seasons of almost all of the important commercial species have been determined, and a large mass of miscellaneous data relating to a great variety of subjects has been accumulated.

Some of the more important results that have thus far been obtained in the investigations are briefly presented here.

SOME FACTS IN THE REPRODUCTION AND LIFE HISTORY OF MUSSELS.

As is well known, the Unionidæ carry their young in the gills, which act as a marsupium or brood chamber until the completion of the embryonic development. The eggs are passed from the ovaries into the suprabranchial chambers, where they are fertilized by spermatozoa brought in by the inhalent current of water. In many species the eggs are bound together in masses by a gelatinous or glutinous matrix which is secreted by the gills and which may be very tenacious. This, however, in most cases gradually dissolves away as development proceeds, until at the close of the embryonic period the larvæ or glochidia are no longer agglutinated. These masses assume in different species many forms of flat plates or cylindrical cords which fill the water tubes of the gills. The latter may be greatly distended or modified in various ways to receive the egg-masses. In some species, on the other hand, the condition

just described is absent and the eggs are either not agglutinated at all or are only loosely held together in a slightly viscid substance.

The extent to which the gills are modified as a marsupium varies greatly in different genera. In many, as in *Anodonta*, *Pleurobema*, *Strophitus*, *Symphynota*, and *Unio*, the entire outer gill of each side is thus utilized and when filled with embryos or glochidia, presents a much swollen, padlike appearance. In others, for example, *Lampsilis*, *Obovaria*, *Plagiola*, only the posterior portion, varying from one-third to two-thirds of the entire outer gill, is used as a receptacle for the eggs, a sharp demarcation existing between the marsupial region and the anterior respiratory part. The former is highly modified in structure and may be readily recognized, even when empty. In *Obliquaria reflexa* a varying number of enlarged and distended water tubes contain the dense, glutinous cords in which the embryos are embedded. Finally, there are at least two genera, namely, *Quadrula* and *Tritigonia*, in which all four gills are utilized as brood chambers. This condition would seem to be the most primitive one, as the gills show but little structural modification and when empty are indistinguishable from those of the male mussel.

In all of the species of the genus *Lampsilis* which we have examined the posterior margin of the valves in the female is less pointed than in the male, and by reason of this difference in the shape of the shells the sexes may be readily distinguished externally. In most of the other genera that have come under our observation, however, the shells of the two sexes are identical, and an internal examination is necessary in order to determine the sex of an individual.

The entire embryonic development takes place within the marsupium, and at the end of this period the glochidium, which has become liberated from the egg membrane within the gill, is fully formed. In those species which are known as "summer breeders," the glochidia are discharged at once, while in many others, the so-called "winter breeders," they are carried in the gills for several months before being set free in the water.

The glochidia, as has long been known, do not complete their development unless they become attached to fishes, and the metamorphosis occurs while they are living parasitically in a cyst formed by the epidermis of the host. After discharge from the marsupium, the glochidia under natural conditions lie quiescent on the bottom, their valves gaping widely apart, and unless chance brings them in contact with a fish they will die. Once attached to the gills or external parts of a fish, however, the rest of the development, if conditions are favorable, is assured.

This unique peculiarity in the life history of fresh-water mussels has been taken advantage of in artificial propagation, as it has been found that a single fish, even though small, may successfully carry to the close of metamorphosis several hundred glochidia. One fish may, therefore, be made to do the work

of a large number in a state of nature, for under ordinary conditions it is extremely improbable that more than a very few glochidia would succeed in attaching themselves to a single fish.

After a parasitic life of variable length, during which the metamorphosis is completed, the cyst breaks down, and the young mussel, thus liberated, falls to the bottom and leads thereafter an independent life.

BREEDING SEASONS.

We have confirmed the conclusion, first reached by Sterki (Nautilus, vol. IX, 1895), that the Unionidæ, with respect to their breeding seasons, fall into two classes, the so-called "summer breeders" and "winter breeders." The latter designation, however, is not strictly appropriate, for in the species which belong to this group the eggs are fertilized during the latter part of the summer, usually in August, and the glochidia, which are carried in the brood chambers over the winter, are not discharged until the following spring and summer. In fact, in some cases the close of one breeding period may overlap on the beginning of the next, as one may still find in late July some females gravid with glochidia, while in others the eggs are passing into the gills for the next season. In the case of the summer breeders the eggs are fertilized during the late spring and summer, and the glochidia are in all probability discharged before the end of August, or certainly not later than the middle of September. In the species of this class of which we have the completest records, ovulation begins in May and early June and may last well into August, but after the end of August gravid females have not been found.

In view of the above facts, it would seem in better accord with actual conditions to separate the species with respect to the length of time that the glochidia remain in the gills, designating them as those which have a "short period" of gravidity and those having a "long period," rather than to distinguish them as "summer breeders" and "winter breeders," respectively, for in the case of the latter neither ovulation nor discharge of the glochidia takes place in winter. The breeding season is undoubtedly a generic character, for, so far as our observations go, all species of a given genus belong to the same class.

The following list shows the distribution, with respect to the period of gravidity, of the genera we have had under observation:

Long period:
- Alasmidonta.
- Anodonta.
- Lampsilis.
- Obovaria.
- Plagiola.
- Strophitus.
- Symphynota.

Short period:
- Obliquaria.
- Pleurobema.
- Quadrula.
- Tritigonia.
- Unio.

As there are important commercial species in each class, the futility of any law which would prohibit the taking of mussels during their breeding season becomes at once apparent, for there is no month in the year when some species are not carrying either embryos or glochidia.

THE LARVA, OR GLOCHIDIUM.

Two well-marked types of glochidia occur in the Unionidæ, one provided with stout hooks on the ventral margin of the valves and the other entirely hookless. The former are characteristically parasitic on the fins and other external parts of the fish, the latter on the gills. We have given special attention to a study of the physiological peculiarities correlated with these two types of structure, including their differences in behavior in attachment.

The occurrence of the two types of glochidia in the genera which we have examined is shown below.

Hookless glochidia:	Hooked glochidia:
Lampsilis (except L. lævissimus).	Anodonta.
Obliquaria.	Lampsilis lævissimus.
Obovaria.	Strophitus.
Plagiola.	Symphynota.
Pleurobema.	
Quadrula.	
Tritigonia.	
Unio.	

It is thus seen that the hookless type is by far the commoner one, and furthermore, practically all of the commercial species of mussels belong to the genera included in this class.

The type of glochidium is constant for the genus, so far as our observations have gone, except in the genus *Lampsilis*, one species of which, *L. lævissimus*, produces glochidia having hooks, while all of the remaining species that we have examined have the hookless forms. The glochidia of *L. lævissimus*, moreover, are of quite a different form from those of any other species we have encountered, being shaped like an axe head when seen in side view.

The hookless glochidia are usually much smaller than those having hooks, and also differ characteristically from the latter in shape.

We have repeatedly determined the fact that the hooked glochidia form permanent attachment as a rule only to external parts of the fish, as the margins of the fins, operculum, anus, and mouth, the barbules, or even to scales and along the fin rays occasionally. Wherever a free border is presented that may be grasped between the valves of the glochidium, attachment is possible, the hooks holding securely as soon as the valves have closed. Hooked glochidia, furthermore, are not infrequently found on the gill arches and rakers, as these places furnish the requisite conditions for a firm grasp. Glochidia of this type,

however, do not as a rule acquire a permanent lodgment on the delicate gill filaments, as their hooks usually tear through these when grasping. Their greater size would also seem to render it difficult for the hooked glochidia to become properly embedded under the epidermis of the slender filament.

Hookless glochidia, on the other hand, are only rarely found on the external parts of the fish, and although they become attached readily to such places, in the absence of hooks their grasp is insecure, and the usual consequence is that they are all soon brushed off. Being hookless and quite small, they are admirably adapted to lodgment on the gill filaments, among which they may become entangled in great numbers.

Interesting differences of a physiological nature also are correlated with the two structural types, apparently in adaptation to their different parasitic habits.

IMPLANTATION OF THE GLOCHIDIA.

Contact with any part of the fish affords the stimulus which causes the adductor muscle of the glochidium to contract and close the valves. This stimulus is purely a mechanical one, as the same result may be produced by touching with any object. In this way they may be caused to snap shut on a bristle or hair, or on the edge of a piece of paper. Once attached to the fish, however, the glochidium exerts a stimulus upon the epidermal cells of the host which causes them to undergo a rapid proliferation. The stimulus in this case is undoubtedly a chemical one, and its immediate effect is to throw the cells of the epidermis into active mitotic division. The epidermis now grows rapidly over the glochidium, which may become completely embedded in three hours after attachment in the case of the gill parasites. The proliferation of the epidermis of the fins occurs more slowly and in this situation twelve to twenty-four hours are usually required before the glochidia are covered.

After the process of implantation is completed, the glochidia are entirely inclosed within the cellular cyst, where they are nourished by the host until liberated by the rupture of the cyst at the end of the parasitic period. It is during this stage of the development that the metamorphosis occurs and the structure of the glochidium is replaced by that of the mussel.

EXPERIMENTAL INFECTIONS.

METHOD.

A very large number of experimental infections have been made, and the conditions determining infection have been investigated as far as the material at our disposal has allowed. This study has included not only the behavior of both types of glochidia, their manner and place of attachment, but the reactions of the fish as well.

Twenty different species of mussels, yielding both hooked and hookless glochidia, have been used for the infections. The majority of these have been species showing the long period of gravidity, although several of the summer breeding species have also been employed. Eighteen species of fishes have been used, and their reactions have been carefully observed, but, as all are not equally favorable for receiving and carrying the parasites, the greater number of infections have been made upon five or six species.

When only a few fishes are to be used at a time, the method which has been employed is quite simple. The brood chambers are excised from the gravid mussels, split open lengthwise, and the ripe glochidia washed and scraped out into dishes of water. The fishes are then placed together with the glochidia in small aquaria, and, if the infection is to be made with gill parasites, the water is agitated by mechanical means, in order to keep the glochidia suspended and thus insure their being taken into the mouth of the fish. When using hooked glochidia for external attachment, however, it is better not to stir them up, as the fishes usually settle down to the bottom of the vessel and, by rubbing their fins among the glochidia, quickly become infected to any desired degree.

When making gill infections, the fishes must be examined at intervals of one or two minutes for the purpose of observing the rapidity with which the glochidia are attaching, and when the degree is reached which experience has shown to be the optimum for the species of fish in question, the exposure is at once discontinued. Usually the gill infections take place very quickly, and in four or five minutes the fishes will have received as many glochidia as they can safely carry, although of course the duration of exposure depends upon the abundance of glochidia in the water. Other things being equal, the fewer glochidia present the more prolonged the exposure must be. Experience has shown that the best results are obtained when the glochidia are used in very "dilute mixtures," for it is difficult to avoid overinfection, if they are at all concentrated. Some species of fishes, however, are less susceptible than others, and a longer exposure is necessary to insure the attachment of an adequate number of glochidia. In certain cases we have had to allow the fishes to remain with the glochidia for from two to three hours, or even longer, in order to obtain a satisfactory degree of infection.

In nearly all of our experiments we have used young fishes, from three to six inches in length, as for many reasons they are more convenient than larger ones.

BEHAVIOR OF FISHES—THEIR SUSCEPTIBILITY AND RESISTANCE.

The fishes when first placed in contact with glochidia give evidence of great irritation, and as soon as the gills begin to be infected they exhibit violent and rapid breathing movements, apparently in the attempt to expel the parasites.

After a time, however, they become quiet, and when removed from the presence of the glochidia behave normally, except that the more rapid respiratory movements may continue even for days afterwards.

The fishes we have used in our experiments have shown marked differences in their ability to retain the glochidia both on the fins and on the gills, more especially on the latter. They vary even more strikingly with respect to their capacity for withstanding the injurious effects of gill infection, and furthermore some fishes are undoubtedly much more susceptible than others, as the glochidia become attached, especially to the gills, more readily.

Of the fishes which we have had under observation, the following species have proved to be the most satisfactory: rock bass, large and small mouthed black bass, green sunfish, and red-spotted sunfish. All of these species are very susceptible and readily infected with gill parasites, large numbers of which may be carried without apparent injury to the fish. A single individual of any of the above-mentioned fishes, not more than 3 or 4 inches in length, will successfully carry at least 1,000 glochidia on its gills to the close of the parasitic period, a number that would speedily kill many other species.

Yellow perch, blue-gill sunfish, and crappie, although quite susceptible, are far less resistent to the injury and quickly succumb to overinfection. Young bullheads are apparently very difficult to infect, and we have not succeeded in causing glochidia to become attached to either their gills or fins in appreciable numbers.

German carp are easily infected on external parts with hooked glochidia, but thus far all efforts to infect this fish with gill parasites have been unsuccessful. The glochidia will attach themselves to the gill filaments, but for some unaccountable reason implantation is imperfect and they soon drop off. Apparently the epidermis of this fish does not react to the stimulus in such a way as to lead to the formation of a permanent cyst.

In still other cases it has been found that failure is due to the fact that, even after complete implantation on either the gills or fins, the walls of the cyst slough away in a day or two and liberate the glochidia. Whether this is caused by unfavorable physiological conditions in the fish or in the glochidia we are unable to say, but there are certain facts that would seem to indicate that such abortive implantations are the result of a physiological immaturity of the glochidia, which therefore fail to call forth the necessary response on the part of the fish's tissues.

DURATION OF THE PARASITIC PERIOD.

The duration of the parasitic period is very variable. With respect to the glochidia of those species of mussels which remain gravid over winter the duration depends upon the time of year when the infection is made. Fishes

infected in the late fall and winter will carry the glochidia for from two and a half to nearly four months, while in spring, when the same kind of glochidia are used, the metamorphosis is completed and the young clams liberated in a little less than a month. This great difference in the length of time that the glochidia remain on the fish can not be due primarily to temperature, although this may have some influence, for we have observed the same differences in the laboratory, where the temperature of the water remains practically constant throughout the winter and spring. As the glochidia of the mussels which have the long period of gravidity are not normally discharged until spring and summer, it is quite possible that the fall and winter glochidia are physiologically immature, although capable of causing the formation of the cyst on the fish, and require for this reason a much longer time for the post-embryonic development. Structurally, however, they seem to be identical with those taken from the marsupium in the spring.

In the case of the spring infections the young clams all leave the fish at about the same time, and within a very few days after the first are liberated the last to go have come off. This is not true, however, of the fall and winter infections, for in these cases the setting free of the young mussels may be extended over a period of three or four weeks, or possibly more.

We have no observations on the duration of the parasitic period in the case of the summer-breeding mussels. Although infections have been successfully made with several of these species and kept under observation for ten or twelve days, we have not yet had an opportunity of following the metamorphosis through to the end. The period is, however, undoubtedly short, probably not more than four weeks. Harms (Zoologischer Anzeiger, bd. XXXII, 1908) has recently recorded a parasitic period for two European species of *Unio*, a genus belonging to the group of summer breeders, of twenty-six to twenty-eight days.

POST-LARVAL GROWTH OF MUSSELS.

No data have been obtained on the rate of growth of fresh-water mussels beyond a short period after the metamorphosis, as we have not succeeded in keeping the young mussels alive in the laboratory for more than four weeks after leaving the fish. The amount of growth during that time was only a fraction of a millimeter. We have made, however, extensive plantings of young mussels which have been allowed to drop off the fishes in ponds and streams where the chances of reclaiming them in the future are very good, and it is hoped that by another year or two some data on the rate of growth will be available. Carefully measured and weighed young mussels of different sizes have also been placed in wire cages and set in ponds and rivers, and it is possible that additional data will be obtained from these experiments.

INFECTION OF LARGE NUMBERS OF FISH.

In order to test the feasibility of infecting large numbers of fish, which is a prerequisite of artificial propagation, an extensive experiment, in which over 25,000 fish were employed, was made at the substation of the Bureau of Fisheries at La Crosse, Wis., in November, 1907. Seven species of fishes and glochidia from four species of *Lampsilis* were used in the experiment. The fishes, with the exception of the German carp and the bullheads, were successfully infected and retained in the tanks of the station for over two months, when they were liberated in the west channel of the Mississippi River at that place. The experiment completely demonstrated the possibility of making infections successfully on a large scale, and of retaining the fish until near the close of the parasitic period.

In November, 1908, a similar experiment was carried out at the station of the Bureau at Manchester, Iowa, where about 12,000 large-mouthed black bass and crappies were infected with the glochidia of several species of *Lampsilis*. The fish were kept at the station for one month and then placed in the Maquoketa River between two dams. As the species of mussels used in the experiment in all probability do not occur in that stream, the results of the work may be determined if we succeed in reclaiming any of them at a future time.

During the fall and winter of 1908–9 infected fishes were put into ponds in the neighborhood of Columbia, Mo., where we are absolutely certain that the species of mussels used do not occur, and where there is every reason for the expectation of subsequent reclamation. The latter experiments should yield valuable data on the rate of growth.

A PLAN FOR PROMOTING THE WHITEFISH PRODUCTION OF THE GREAT LAKES

By S. W. Downing

Superintendent U. S. Fisheries Station, Put-in Bay, Ohio

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908

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In discussing this subject it will first be necessary that we understand something of the habits and the manner of reproduction of these fishes, and the probable increase and losses in numbers under natural conditions. Since the same conditions exist and the same reasoning will apply to all the lakes of the chain, we will confine our remarks to the conditions in Lake Erie.

BREEDING HABITS AND NATURAL REPRODUCTIVITY OF WHITEFISH.

The adult whitefishes are migratory, leaving the lower end of the lake and the deeper waters each year as the spawning season approaches and the breeding instinct prompts them, and seeking their natural spawning beds, which consist of the reefs among the islands and the rocky and sandy bottoms of the shoaler portions of the lake. Most of these reefs and shoals are of that peculiar formation called honeycombed rock; that is, instead of being gravelly or smooth these rocks are dotted with holes and small cavities into which the eggs, as they are voided by the fish, may drop and be comparatively safe from being eaten by the suckers and other spawn-eating fishes, water lizards, or other enemies, and also from being covered by mud, silt, and other filth, and smothered, as they would be if deposited on mud bottom.

Were the whitefish nest builders, and did they pair as some of the other fishes do so as to perform the function of fertilizing their eggs with any degree of certainty, the chances for a large production of young under such favorable conditions would be very good, indeed; but they are not nest builders, neither do they mate; on the contrary they approach the spawning grounds singly and in schools, and are what is known as "school spawners," the female extruding her eggs wherever she may happen to be, regardless of whether there is a male fish within close proximity or not. In consequence but very few of the fish come together so as properly to perform the functions of fertilization; and when it is

known, as was demonstrated by Mr. J. J. Stranahan by a very careful experiment in the fall of 1897, that the life of an unfertilized whitefish egg, if left in the water, is less than 4 minutes, while more than 50 per cent of them perish in 1½ minutes, and the life germ contained in the milt of the male fish may be fairly supposed to live no longer under the same conditions, it will readily be seen that the percentage of eggs fertilized under natural conditions must of a necessity be very small. In fact, it is estimated by those fish culturists who have had most to do with the propagation of whitefish that not more than 1 per cent of the eggs are fertilized when deposited under natural conditions. At this rate let us see how many fertile eggs each pair of whitefish will produce each season.

It is estimated that the average number of eggs produced annually by each female whitefish is 35,000. The greatest number the writer has ever known to be secured from one fish was 150,000, from a fish weighing 11 pounds, giving 13,636 eggs to the pound of fish. This would be equivalent to a little more than 37,000 eggs from a fish weighing 2¾ pounds, and as the average weight of the spawning whitefish is from 2½ to 3 pounds it will be seen that 35,000 eggs to the fish should be nearly correct. Then if each pair of whitefish produce 35,000 eggs, and but 1 per cent of them are fertilized, 350 fertile eggs to the pair is all that can be expected to commence with. As the period of incubation for whitefish eggs is from 128 to 150 days, and as these fertile eggs must lie on the lake bottom all this time, in danger of destruction by being smothered in mud and filth as previously shown, and exposed to the still greater danger of being eaten by all kinds of aquatic animals that feed at the lake bottom, it is quite evident that but few of these 350 fertile eggs will survive to reach the fry stage.

It is evident, moreover, that nature never intended there should be such a large increase in numbers as would result from anything like a perfect fertilization, for in that case the lake in a short time would be so densely inhabited that the waters could not produce sufficient food for all; neither would there be room in the lake for them if they came to maturity. It is therefore safe to suppose that naturally the number increases but little if it more than overbalances the loss, and reasoning from the known to the unknown we are sure that this is true.

The number of young produced each year by those fishes, of which there is a large family, that carry their young through the period of incubation and produce them alive, ranges, so far as the writer has been able to learn, from 1 to 22, giving an average of 11 young to each pair of fish; and as these fishes are very numerous where found, it appears that this rate of increase in the fry state is sufficient to more than overcome the losses under natural conditions. Thus by analogy we have the proof that an increase of 11 young from each pair of fish of any kind, including whitefish, is more than enough to overbalance the natural losses.

WORK OF THE HATCHERIES.

But the whitefish, on account of being such an excellent food fish, is more sought after than many others and is taken by every device that man has been able to invent and in the greatest numbers possible on all occasions, so that the natural losses are many times multiplied by this take of fish which may justly be termed "artificial" losses. If this artificial loss is continued, then in order that the loss shall not greatly overbalance the natural increase there must of necessity be introduced an artificial increase. Happily this can be accomplished, in fact is being accomplished, in several places by the aid of the hatcheries. The method employed is to have men go out with the commercial fishermen when they raise their nets and collect the eggs from the ripe fish. This is done by expelling the eggs into a common milk pan in as dry a state as possible, after which they are immediately fertilized by using the milt of the ripe male fish. They are then carefully washed, brought to the station and placed in the hatching jars, where they remain until hatched. In addition to this method of saving the eggs we also pen several thousand fish each year. To do this a net is hung on the back of that part of the pound net called the crib, and when the fish commence coming on the grounds, before they are ripe enough to spawn, the fishermen as they raise their nets take out the unripe fish and place them in these nets on the back of the crib. The station tug, which is provided with large tanks through which a stream of water is constantly pumped, visits these nets and takes the fish out, transferring them to the tanks and conveying them to the station, where they are then transferred to the pens. Here they are held until they ripen, when the eggs are secured; and the fish after a few days, when they have regained their normal condition, are returned to the fishermen from whom they were obtained and are sent to market. It is perhaps well to say in this connection that spawning the fish in this manner in no way injures them for food—in fact these fish that are spawned and then held a few days before being put on the market are in much better condition for consumption than if they had been marketed when first caught. Moreover, the whitefish, unlike many others, is in the best condition for food at spawning time, for the reason that it is very fat and the flesh is juicy, sweet, and, the water temperature at this time being low, firm and flaky, while earlier in the season when the water is yet warm the flesh is much softer and not of as fine a flavor.

Not to digress further, however, we will continue by saying that from the fish collected and held in pens as described above, at one point alone last season over 47,000,000 eggs of the very best quality were secured. In other instances, where the fishermen operate on a small scale and small boats are used for the purpose, arrangements are made whereby the fisherman collects the eggs himself

and is paid for them at so much per quart for fertile eggs. These men operate gill nets and fish on the reefs, and as the whitefish do not frequent the reefs to any extent until ready to spawn, usually more than 50 per cent of their catch is ripe fish.

MEASURES NECESSARY TO INSURE INCREASED PRODUCTION.

From a practical experience of sixteen seasons in the hatching of whitefish and by consultation with other fish culturists, we find that the average hatch of the eggs collected and taken to the hatcheries is from 75 to 80 per cent. Assuming the lower figure to be the correct one, if each pair of whitefish, as previously shown, produce 35,000 eggs, by the assistance of the hatcheries we get three-fourths of 35,000 or 26,331 fry as against the 11 the same fish would have produced if the eggs had been left to themselves, or 2,393 times as many as it was intended by nature for them to produce, as just now shown. Even allowing that the whole of the 1 per cent naturally fertilized hatch, giving 350 fry as the number produced by each pair of fish, the hatchery would still beat nature by 25,981 fry or 750 times as many, and the fry produced in the hatcheries are just as strong and vigorous and their chances for reaching maturity are just as great as are those hatched naturally. Then, if by the lower calculation we produce 750 times as many fry by collecting the eggs and hatching them at the hatcheries as the fish would produce if left to themselves, it is obvious that the best plan to promote the whitefish production of the Great Lakes is:

To so arrange matters that artificial propagation shall be generally applied to reproduction by having hatcheries established at every available point where a sufficient number of eggs can be secured to warrant their maintenance. It is not necessary that the hatcheries be operated on as large a scale as those at Detroit and at Put-in Bay, but wherever enough eggs can be secured to give a hatch of from 25 to 50 millions, if these points are remote from the larger stations put up a hatchery and operate upon as economical a scale as possible; to stock these hatcheries not only collecting the eggs from the ripe fish as caught by the fishermen, but penning and holding the green fish until they ripen, pursuing the method just described, so that practically all the fish caught will have contributed toward this production before being placed upon the market.

To make this plan the more effective, so as to get the greatest increase possible from the fish caught, a law should be enacted compelling the fishermen to collect, or allow the hatcheries to collect, all the eggs from the ripe fish, and to place the green fish in the auxiliary nets for penning; the fishermen to be paid a fair price for the eggs so taken by them and for their trouble in penning the fish, and to receive a fair remuneration for all fish lost by penning.

As a further part of the plan we would have a law enacted prohibiting the taking or the offering for sale of any undersized whitefish, making the size limit large enough so that every fish before being placed upon the market would have had a chance to have spawned at least once and thereby contributed toward increasing the production.

This plan should not only be universal with the states bordering upon the Great Lakes, but should be international, making the same conditions on the Canadian side as in the states and preventing any loophole through which the regulations could be evaded.

This plan would be strengthened by making a closed season during the summer months when it is so nearly impossible to get the fish to market in an edible condition on account of the warm weather and the high temperature of the water from which they must of a necessity be taken. All the fish so taken are a total loss to reproduction, as they go to market with all their unripe eggs still in the ovaries, and for every female whitefish taken at this period there is a loss to reproduction of 11 to 350 fry if left to spawn naturally, or of approximately 26,000 if the eggs were allowed to ripen and hatch at a hatchery.

If this plan is adopted, the writer will cheerfully stake his reputation as a fish culturist that at the end of ten years it will have been proved the best offered up to date.

A PLAN FOR PROMOTING THE WHITEFISH PRODUCTION OF THE GREAT LAKES

By Frank N. Clark

Superintendent U. S. Fisheries Station, Northville, Mich.

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In preparing the following discussion I considered it desirable to eliminate as far as possible the complicated and tiresome statistical details which, in almost every paper of this nature, go to make up a great portion of its subject-matter. I believe that the interest of those who may be called upon later on to devise some effective means of increasing the supply of this greatest of all American food fishes will be more easily aroused by demonstrating a simple and practicable solution of the problem. Some figures are necessary, of course, but in most instances I have made bold assertions of facts which I know to be true, and which I am going to take the liberty of asking my audience to accept for the truth.

CONDITIONS OF THE FISHERY AND THEIR CAUSES.

It is a universally conceded fact that in an early day when the forests of the states and provinces bordering upon the Great Lakes were for the most part still in their primitive splendor, when the rivers and streams emptying into these waters ran clear as crystal and when civilized man had not yet turned so extensively to the waters for his livelihood, whitefish were in very great abundance and were distributed in a wide range throughout the entire water system known as the Great Lakes. Even as late as from 1864 to 1870, as may be noted by reference to Mr. J. W. Milner's report in the Bulletin of the United States Fish Commission for the year 1872, whitefish were present in such large numbers that during a single season it was not unusual for a fishing ground to yield from 200 to 700 half barrels for each pound net in operation. In a long and very interesting conversation which I had a few years ago with a Mr. Woodward, who was then a very old man, I learned that sometime during the early fifties, while he was acting as a government surveyor and maintaining a camp at the mouth of the Thunder Bay River, his party caught more whitefish than it could use and took them all from the river itself. At the present time no whitefish

are caught within 9 miles of the river's mouth. In 1867 and 1868 my father, the late N. W. Clark, who was one of the pioneer fish culturists of America, took whitefish spawn on the Detroit River, and his observations made at that time indicate that the species was very abundant. At Grassy Island and Mama Juda, two of the best-known fishing grounds, 1,000 fish at a haul was no unusual occurrence. At the present time a haul of 30 fish is considered large. The same is true also of the Au Sable region upon Lake Huron, where during the sixties from 40 to 50 boats were doing a very lucrative business and at the present time not more than a half dozen are operated with only indifferent success. In varying degrees this same decrease in numbers has taken place upon every fishing ground of the Great Lakes, in a great many places to such an extent that operations have been entirely abandoned.

Why should this be so? If we can answer this question, and if the causes can be eliminated or in some measure restricted and controlled, we will have found a solution of our problem in so far as a solution is possible.

First. The cutting of our forests and consequent floods and erosion of the soil, the discharge of sawdust and other refuse from the lumber and pulp mills, chemical works, and sugar factories, which go to make up the industrial life of the cities situated on the Great Lakes, have made the deposits from the mouths of our rivers offensive to the dainty senses of the whitefish and have gradually encroached upon its spawning and feeding grounds to such an extent that in thousands and thousands of acres which at one time were teeming with this species it is now an absolute stranger. This damage can not now be undone, but by wise legislation the cause of it may be to some extent prevented from further offenses.

Second. The operation of the commercial fisheries under unwise laws and the nonenforcement of good laws has, in my judgment, contributed in a greater degree toward the decrease of the whitefish than all of the other causes put together. Most of the law-making bodies of the states bordering upon the Great Lakes have put the cart before the horse, so to speak. By their enactments they have permitted the taking of this fish at all times except during the spawning season and the period of incubation, which all students of fish culture insist is a kind of alleged protective legislation that does not protect. If we are to have closed-season laws they should cover the month or months when the largest lifts of unripe fish are made. It is then that our whitefish need protection, for their ova are immature and we can not half so well spare the parents as we can during the spawning season. When unripe adults are caught for market all their spawn is necessarily wasted, whereas if protected until the spawning season the different commissions would be given an opportunity to save the ova, hatch the fish, plant them in the lakes, and thus by artificial propagation cause each ripe female to furnish thousands of her kind. We have

hatcheries to care for the ova, and, if the present number is insufficient, let us build and equip others; in any event let us not expect nature to make a complete revision of her fundamental laws merely to accommodate herself to the lack of foresight and the inconsistency of mankind.

We need no protection for mature fish, except, as above stated, during the months when the largest lifts of unripe fish are made. The young fish should be protected against the adults. These are the enemies and food competitors of the growing generations, and the quantity of food that a dozen adults consume will suffice for the support of thousands of fry. The question may properly be asked, do the fry subsist upon the same individual food that the adults require? Strictly speaking, they do not; but the source from which the growing generations derive their food supply is at least indirectly dependent upon the higher groups which the adults do destroy.

For these reasons, therefore, I contend that the so-called closed-season laws as they now exist are all wrong. Of course, I am not one of those enthusiasts who believe that our lakes may be made to teem once again with the countless millions of the early days, even with the assistance of the wisest possible legislation and most successful artificial propagation. The conditions have been changed and I know of no way whereby they can be restored. The formerly vast and almost unlimited areas of spawning and feeding grounds have been gradually destroyed by sawdust, bark, slabs, water-logged timber and other refuse, and the water for miles out from shore in the neighborhood of cities and towns is constantly being polluted and infected by poisonous sewage and other impurities. Because of these unfortunate conditions the present spawning and feeding grounds are confined to a few localities.

REMEDIAL MEASURES.

But that the whitefish of the Great Lakes can be increased very materially in spite of these difficulties which the fish culturist is forced to encounter I am very strongly convinced. This can be done only by closely adhering to some such plan of action as I shall outline in the remainder of this paper, and which I contend, and shall endeavor to convince my hearers is the only possible solution of the problem.

(1) INTERNATIONAL PROTECTIVE LEGISLATION.

First, there must be concerted action, by means of a treaty or otherwise, on the part of the United States Government and the Dominion of Canada, and such action must be carried on to the point where there shall be one set of laws applicable to all the waters of the Great Lakes and their tributaries, and enforceable on the part of either government in any part of its own or

the other's territory. I would also repeal and abolish all of the existing laws of the several states and provinces in so far as they deal with the food fishes of the Great Lakes, so that the question of proper authority and jurisdiction could never arise. The greatest advantages to be gained by thus placing the Great Lakes under the control of the two governments would be the more rigid enforcement of the laws and the removal of legal proceeding from the universally conceded local influence over local juries. A uniform law such as I deem to be adequate to afford the fullest measure of protection for the whitefish should be framed along the following lines:

(1) Issue to the present United States and Canadian fishermen, or to anyone who shall subsequently apply therefor, a revocable license to fish the waters of the Great Lakes and their tributaries; such license to be suspended for six months for the first violation, one year for the second, and forever forfeited without hope of reinstatement upon a third violation of the protective laws.

(2) Provide for an open season during the months when the fish are spawning and a closed season during the month or months when the largest lifts of unripe fish are made.

(3) Prevent any sort of fishing in certain localities where large numbers of immature fish congregate upon the feeding grounds, this legislation to pertain to all portions of the Great Lakes system where the presence of such fish has been established and to be enforced during such month or months as they make their appearance in large numbers for feeding purposes.

(4) Prevent the sale or offering for sale or the use of immature whitefish in any manner except for charitable purposes, the size of a mature fish to be legally fixed for this purpose at 2½ pounds. This would discourage the capture of immature fish and protect them upon their feeding grounds, where they assemble in schools.

(5) Make no restrictions of any kind whatsoever as to the kind of nets or the size of the mesh which the fishermen may use in their operations, because, in my judgment, the provisions of this character which are now a part of the present local laws have furnished even more opportunities for the fishermen to escape conviction than the influence upon local juries. Rigidly enforce the provisions regulating the size of the fish which may be sold, and the size of the mesh, kind of net, and manner of capture will be regulated by the fishermen themselves.

(6) As a part of this legislation let there be a provision requiring all fishermen who operate in the territory comprising the Great Lakes and their tributaries to take and fertilize all of the spawn contained in every ripe female that is caught during the spawning season, further details of which plan I shall discuss under another topic.

The above-outlined six provisions would, in my judgment, constitute an adequate law for the greatest protection and consequent increase of the whitefish that it would be possible to give them. If a uniform law can be agreed upon and framed along these lines, and then enforced with the same watchful diligence with which the revenue laws of both countries are enforced to-day, there is no room for argument against the statement that, aided by artificial propagation on a large scale, the whitefish may be increased so materially that at no very distant future date the fisherman's net will be found to contain dozens where there is one to-day.

(2) ARTIFICIAL PROPAGATION.

Now while a uniform, adequate, and rigidly enforced set of laws is of the greatest necessity in bringing about a material increase in the whitefish, propagation upon a large scale is absolutely indispensable. That artificial propagation of the whitefish as it has been worked out and practiced during the past twenty years by the several states and the United States and Canadian governments has been the means of effecting an actual increase of this species, there is at this day no one so bold that he dare dispute. Statistics have been prepared and published which show that until within the past six or seven years from two-thirds to three-quarters of all plants of whitefish fry have been in Lake Erie and the Detroit River, and the fact is well known that in these waters there has been a large increase in their numbers. The United States Government during its operations at Belle Isle and Grassy Island in the Detroit River for the past few seasons has taken from 25 to 50 per cent more whitefish at these points than the Michigan Fish Commission did a decade ago, the fishing continuing for no longer a period each season and being with the same kind and length of seines.

Now, by artificial propagation on a large scale I mean the production of whitefish fry in such numbers that every suitable locality on the Great Lakes may have the same, or, if possible, greater opportunities to assist in this increase than have been afforded Lake Erie and the Detroit River. This would involve the planting of from two to five billion fry annually, and the following plan, if adopted, would easily furnish, in my judgment, a sufficient number to bring about the required results:

Every fisherman operating in the waters of the Great Lakes should be required to strip every ripe female caught during the spawning season and impregnate the eggs taken therefrom. This would operate as an annual tax upon the fishermen, the expense being probably from $25 to $100 per boat. At the present time from 50 to 75 per cent of the fishermen are perfectly familiar with the methods employed in successful spawntaking, and there

would be very little difficulty in having the inexperienced taught by the experts in the employ of the two governments. After impregnation all of the spawn should be turned over to United States and Canadian government agents for shipment to the several hatcheries, where the eggs could be cared for and the fry distributed in a wide range throughout the entire Great Lakes system. The eggs taken by each fisherman should be measured and kept separate from the others throughout the incubation period. This would involve but very little additional labor and would be of very material assistance to those agents of the two governments upon whom would be placed the responsibility of enforcing the protective laws; and such a record would not only show exactly which fishermen were improperly impregnating the eggs taken, but by comparison with the size of their catch during the spawning season it could be satisfactorily determined whether or not they obeyed the law prescribing that all ripe females should be stripped. Of course, a fisherman might be the victim of ill luck throughout one season, but a recurrence of an unsatisfactory showing would put him under suspicion, and with the penalty of a forfeiture of his license hanging over his head he could be very easily made to see the error of his way. Finally, the Detroit River must be closed to all fishing at all times, except with rod and line, and must be constituted a joint government reservation, controlled and used by the two governments for collecting stations.

If the present facilities for handling the product from these two sources are not sufficient, hatching and distributing stations can be arranged for easily and without any great amount of expense. Such a station with a producing capacity of 50,000,000 fry can be constructed and equipped at a cost not exceeding $1,500, and the same can be operated at an annual expenditure of $500.

This is my plan, in the rough to be sure, but with its essential outlines sufficiently distinct to make the work of preparing and putting into execution an adequate system for the proper protection and consequent increase of the whitefish in the Great Lakes a comparatively easy task. It is self-evident that, inasmuch as the life and growth of the whitefish industry of our inland seas are directly dependent upon the maintenance of supply, the plan which will best promote the industry will be the one which will insure the greatest increase in the species.

A PLAN FOR PROMOTING THE WHITEFISH PRODUCTION OF THE GREAT LAKES

By Paul Reighard

University of Michigan, Ann Arbor, Mich.

Paper presented before the Fourth International Fishery Congress held at Washington, U. S. A., September 22 to 26, 1908, and awarded the prize of one hundred dollars in gold offered by the Wolverine Fish Company, of Detroit, Mich., for the best plan to promote the whitefish production of the Great Lakes

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APPROACH TO THE PROBLEM.

In attempting to devise a plan for the promotion of the whitefish production of the Great Lakes it appears that certain avenues of approach available in the case of cognate problems are in this case closed. This will perhaps become clear if we first consider the possible modes of accomplishing the purpose. The procedures that suggest themselves are those which might be followed in any like problem, and may be conveniently grouped in the following way:

Preservative measures:

1. Prevention of the water pollution which may occur through the agency of sewage, garbage dumps, sawdust or other manufacturing refuse, cinders, ashes, and other refuse from steamers and other boats.
2. Restriction of fishing operations (limitations on fishing season and on character and number of nets to be used).

Restorative measures:

3. Distribution of fry.
4. Introduction of improved races of whitefish.
5. Increase of the food of the whitefish.

Experiments on the effect of water pollution on fish have been conducted abroad and are summarized by Professor Prince (1900). The investigations carried out for the Canadian government by Mr. Knight (1901 and 1907) on the effect upon fish of the pollution of Canadian streams by the refuse of sawmills, pulp mills, gas works, and nail mills are noteworthy, but do not appear to have any application to the Great Lakes. In this country we appear to have no similar published investigation, so that we have no means of knowing the extent of water pollution in the Great Lakes or its effect on the whitefish. We are therefore compelled in this paper to disregard a possible means of increasing the whitefish production through the prevention of water pollution.

When it is desired to increase the production of domestic plants or animals, this is often most readily done by increasing the food supply. In other cases the result may be accomplished by creating a race of larger individuals, or one that breeds more rapidly. These two methods have been applied to domestic forms, but the first of them is often made use of also with game birds and mammals. The whitefish of the Great Lakes lives at depths of from 10 to 50 fathoms, scattered over an area of 25,700 square miles. (See p. 653.) Our knowledge of its mode of life, its daily and yearly movements, and its whereabouts during the growth period is meager. It is impossible, therefore, with present knowledge and under existing conditions, to attempt to increase the natural food of the whitefish. To suggest that it may be possible to produce a race of whitefish that would breed more rapidly than our present race, or appropriate food not utilized by the present whitefish, or occupy areas of the lake bottom now barren of whitefish, is to state a problem the solution of which must lie far in the future. The breeding of improved races of fish must begin with forms more readily controlled than the whitefish. There remain but two methods by which we may hope to increase the whitefish production of the Great Lakes, namely, to greatly increase the number of artificially hatched fry introduced into the lakes annually or to enact restrictive legislation which shall prevent the further depletion of productive waters and shall at the same time give an opportunity for depleted waters to become again productive. The present paper attempts a discussion of these two methods (2 and 3 of the foregoing analysis).

METHOD OF INVESTIGATION.

In undertaking an inquiry of this sort it is impossible to make personal investigation of the whitefish in the field. The vastness of the areas involved and the depth at which the fish lives precludes this in the case of the individual investigator. He must necessarily base his work on data gathered by those who have worked with the help of the various state and national governments bordering on the Great Lakes. The problem is essentially one of statistics. The investigator wishes to know what amount of whitefish have been taken in each part of the Great Lakes over a long period of years; what kinds and quantities of nets have been used in their capture; under what legislative restrictions these have been used; what quantities of young fish have been introduced into the Great Lakes and into each part of them to replenish the waters from which the adults have been taken.

Fishing operations are carried on, or have been carried on, wholly by private individuals or corporations in the waters of the following States: Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin, as well as in the waters of the Dominion of Canada. The fishery laws of these various governments are diverse, and have been changed from time to time in the past. It is

therefore difficult to find any well-defined area in the American waters of the Great Lakes which has been fished under uniform conditions for a period sufficiently long to permit conclusions to be drawn as to the effect of that fishing.

Not only have the conditions under which the fishing has been carried on varied from time to time in any one locality and at any one time from locality to locality, but no complete records are available of the fishing operations in the Great Lakes as a whole, or in any single lake, except Lake Huron, for any continuous period of years. The United States Fish Commission (now the Bureau of Fisheries) has caused statistics to be collected on the fisheries of the Great Lakes about once in five years, and these are available for the following years: 1880, 1885, 1890, 1893, 1899, 1903. The Michigan fish commission has since 1891 employed a statistical agent, who has annually visited each fisherman and personally taken from his books the records of the fish caught and of the nets used. The Canadian Department of Marine and Fisheries has for the past thirty-eight years published in its annual report detailed statistics of the fisheries in Canadian waters. The remaining governments, with the exception of Pennsylvania, are able to afford no information about the fishing operations within their borders.

Not only is investigation hampered by the paucity of statistics, but the reliability of the available statistics is often a matter of serious question. The difficulties in dealing with whitefish statistics arise from two sources. Even when statistics are available for like periods and over the same areas they are often widely at variance. The Michigan statistics are taken annually by a statistical agent who is in the field almost constantly and who by his long service, begun in 1891, has gained the confidence of the fishermen. They are taken under a law which requires the fishermen to make sworn returns of their catches. Considering all the circumstances, they are probably as accurate as such statistics can be made. The data that it has been found possible to use in this paper are chiefly those of the Michigan and Canadian fisheries.

The second source of difficulty referred to has to do with the use of the term "whitefish." Four fishes of commercial importance are referred to as whitefish. These are the common or true whitefish (*Coregonus clupeiformis* Mitchill), the longjaw (*Argyrosomus prognathus* H. M. Smith), the blackfin, bluefin, or bloater (*Argyrosomus nigripinnis* Gill), and the Menominee whitefish (*Coregonus quadrilateralis* Richardson). Subsequent to 1891–92 these forms are distinguished in the statistical reports of the United States Fish Commission, but previous to 1893 "whitefish" only are mentioned. The published reports of the Michigan Fish Commission, as well as the unpublished records of their statistical agent, exclude menominees, blackfins, and longjaws from the rubric "whitefish," which therefore includes only true whitefish. The statistics collected by the Department of Marine and Fisheries of the Dominion of Canada, I am assured, include true whitefish only and exclude longjaws and blackfins. Our com-

parisons are therefore necessarily limited to the whitefish production of those waters that lie within the borders of the Dominion of Canada and of the State of Michigan for the period 1892 to 1906, inclusive, and to the Great Lakes as a whole for the years subsequent to 1893. In the latter case, however, statistics are available only at five-year intervals.

The distribution of whitefish fry is carried on at the expense of the state and national governments, and the annual official reports therefore contain full statements as to the number of fry distributed and the location of each plant. Whitefish fry have been distributed by the states named above with the exception of Illinois, Indiana, and Minnesota, and by both of the national governments, although the states of Ohio and Michigan have not distributed whitefish fry in recent years.

By combining the statistics of the Michigan fisheries with those of the Dominion of Canada, complete returns are available of the catch of whitefish and of the nets used for Lake Huron for the years 1892 to 1906, inclusive. The exact number of pounds of whitefish brought in by each fisherman on this lake and the precise length of the nets used in the lake are recorded for each of these fifteen years. The plant of whitefish fry in this lake may be obtained by combining the figures of the Michigan and Canadian plants for the whole lake or for any part of it. We may thus study in this lake, or in any part of it, the effect of the distribution of whitefish fry on the catch of adult fish for a period of fifteen years. By comparing Canadian and Michigan waters for the same period, we may study the effect on the production of whitefish of certain restrictive enactments which have been enforced in Canada but not in Michigan. By similar methods we may study certain areas in Lakes Superior, Michigan, Erie, and Ontario, from which we have statistics from either Michigan or Canadian sources.

In statistics of the catch of whitefish, figures of single years have little significance, since the catch of one year may be large owing to the weather conditions of that year having been favorable for fishing, while the catch of another year with which the first may be compared may be small owing to unfavorable weather conditions during that year, or the market price in one year may have been high, with a consequent stimulation of fishing operations, while in another year it may have been low, with a consequent curtailment of those operations. These annual fluctuations make it necessary to compare with one another not single years but periods of years. In the present paper market fluctuations are not considered, since the price of whitefish does not tend to fluctuate but rather increases steadily, while by comparing the average outputs of the three successive five-year periods comprised in the years 1892 to 1906, inclusive, an attempt is made to avoid the errors introduced by annual variations in the weather of the fishing season.

The condition of the fisheries is usually expressed by giving the annual catch, but as was pointed out by Rathbun and Wakeham (1893), "the best statistical test of a decrease is a comparison of the average catches per unit of apparatus for the several years for which statistics are available." In comparing the catches of different periods I have therefore reduced the average catch of each period to "pound-fathoms" by dividing the actual catch expressed in pounds by the length of gill and pound nets expressed in fathoms. I have thus obtained the catch in pounds per unit of net length. Unfortunately in making these calculations I have been unable to separate the gill and pound nets which have taken whitefish from those which have not, so that the values given in the tables in this paper are the lengths of all gill and pound nets used in the waters in question whether the nets have or have not taken whitefish.

I have attempted, also, to consider the output of whitefish in its relation to the areas of the Great Lakes bottom occupied by them during that season of the year when they are not migrating. By dividing the number which expresses in pounds the catch of a lake or of any part of a lake by the number of square miles of lake bottom ordinarily occupied by the fish in question, I have obtained a pound-mile unit which is made use of in another part of this paper, where also the method of measuring the areas is described. By the device of the pound-mile it is hoped that in a measure errors have been avoided which arise from the comparison of the catches of different years when the areas fished over in those years have not been the same.

The present paper then attempts to utilize the available statistics in an examination of the individual Great Lakes and of parts of lakes to see what lessons may be learned by a comparison of those areas which have been fished under one set of regulations with those that have been fished under a different set of regulations, and by a comparison of those areas which have been abundantly planted with those that have been less liberally treated. I am indebted to the United States Bureau of Fisheries for kindly obtaining information for me from the states of New York and Pennsylvania, to the Wisconsin Fish Commission for information furnished, to the Michigan Fish Commission for permission to make excerpts from the original records on file in their office and as yet unpublished, and to the Department of Marine and Fisheries of the Dominion of Canada for printed documents and excerpts from official records.

NATURAL HISTORY OF THE WHITEFISH.

SOURCES OF INFORMATION.

In the report of the joint commissioners relative to the preservation of fisheries in waters contiguous to the United States and Canada, Messrs. Rathbun and Wakeham (1897) have collected a large amount of evidence concerning the

habits of the whitefish. This evidence, which is summarized in the report referred to above, consists of the statements of fishermen as to the depths at which whitefish are taken in the different lakes, their distribution, migrations, and other habits. This report, together with the statements of Prof. H. B. Ward in his report on Lake Michigan in the Traverse Bay region (Ward, 1896) form the basis of the following account. The earlier works of Milner (1874) and Smith (1893) have also been consulted.

KINDS OF WHITEFISH.

By the term whitefish as used in this section of the present paper is to be understood the true whitefish or common whitefish (*Coregonus clupeiformis* Mitchill) unless otherwise stated. Fishermen, while they distinguish readily between the true whitefish and other related species, nevertheless often report them together as whitefish and statistical reports are necessarily based on their statements. Thus in the most recent statistical reports of the United States Bureau of Fisheries, Alexander (1905) separates whitefish, longjaws, and bluefins in Lakes Superior and Michigan, and whitefish, longjaws, and menominees in Lake Huron, but lists whitefish only in Lakes Erie and Ontario, although the latter lake, at least, contains longjaws (Smith 1895). The Michigan and Canadian statistics refer to whitefish only. The data used in the present paper are those which refer to true whitefish only.

DEPTHS AT WHICH WHITEFISH OCCUR.

The following statements as to the depths at which whitefish are found are taken from Rathbun and Wakeham (1897) except that for Lake Michigan, which is from Ward (1896):

	Fathoms.
Lake Ontario	10–20
Lake Erie	12–30
Lake Huron	10–35
Lake Michigan	12–20
Lake Superior	10–50

The depth data given for Lake Michigan are specifically stated by Professor Ward to be depths of the true whitefish in summer, and to be the range over which the fish is the most numerous. It occurs in small numbers in both shallower and deeper water. The depths given for Lakes Ontario and Erie are no doubt also those at which the true whitefish is found during the greater part of the year. The greater depths given for Lake Huron possibly cover also the range of the longjaw, which is stated by Ward to occur in greatest abundance from 20 to 25 fathoms in Lake Michigan, although Smith (1895) states that in Lake Ontario they range as deep as 116 fathoms and in August as shallow as 20 fathoms. The range in Lake Superior also possibly covers more than the

true whitefish, but this is uncertain. It may cover in part the range of the blackfin (*Argyrosomus nigripinnis*), which is stated by Ward to be in Lake Michigan rare in less than 40 fathoms. I have placed the inshore range of the whitefish of Lake Superior at 10 fathoms, although Rathbun and Wakeham make no statement on this point, but say merely that the fish ranges "outward into depths of 40 to 50 fathoms, seldom farther, and in some places coming close upon the shore during the spawning season and in the spring." I have assumed the inshore range on Lake Superior to be about the same during most of the year as in the other lakes.

The most careful investigation of the food of the whitefish and of the related fishes we owe to Ward (1896), who finds as a result of the examination of 14 individuals taken in summer that on the average 63 per cent (by volume) of the food of the true whitefish consists of small bottom crustaceans, 26 per cent of small mollusks, 5 per cent of insect larvæ and 2 per cent of small fish. Small brown stones were also found commonly in the stomachs. "The considerable part played by the mollusks and insect larvæ, both of which are strictly bottom forms, shows that the common whitefish is to a large extent a bottom feeder. This view is strengthened by the down-pointed sucker-like mouth of the fish as well as by the presence in the stomachs of numbers of small stones, which were undoubtedly snapped up with some morsel of food" (Ward, 1896). The food of the longjaw Ward found to consist of small crustacea to the extent on the average of 97 per cent of the whole (volume), while the food of the two specimens of blackfin examined contained crustacea to the extent of 97 per cent of the volume. The absence of stones, mollusks, and insect larvæ from the stomachs of these two forms and the presence in them of free swimming crustacea, as well as the form of the mouth of the fish themselves, show that they feed not on the bottom, but just above it. All of these whitefishes therefore feed on the bottom or just above it, but differ in their depth range during the greater part of the year, the true whitefish ranging from 10 fathoms outward, but rarely being taken in more than 35 fathoms, the longjaw ranging from 20 fathoms outward, occurring in greatest abundance between 20 and 25 fathoms and reaching in winter a depth of 116 fathoms, the blackfin occurring rarely in less than 40 fathoms and most abundant at 70 fathoms and upward.

The ranges indicated above as occupied by the whitefish are its feeding grounds during eight or nine months in the year. It enters shallow water in the southern lakes in June and July, and returns again to the deeper water about the 1st of August. The cause of this shoreward migration is discussed by Milner (1874), but he does not mention one very probable cause, namely, that the period of this shoreward summer migration is that when the insect larvæ upon which the migrating fish feed (Kiel, 1874) are most abundant. It is quite possible that the migration takes place as a search for a more abundant

food. The summer migration of the whitefish occurs apparently in all the Great Lakes. Milner (1874) reports it in Lakes Superior, Michigan, Huron, and Ontario, and Rathbun and Wakeham (1897) report it in Lake Erie. The date of its occurrence no doubt varies with the latitude. A second inshore migration occurs in the fall, taking place in November in the more southern latitudes and occupying about a month in any latitude. It is the spawning migration, during which the fish visit the shallower water to deposit their eggs. From Lake Erie this migration formerly extended to the St. Clair River and Lake St. Clair and it still extends into the Detroit River, but in the other lakes the location of the spawning grounds and the related extent of the migration are little understood.

Milner states (1874, p. 85, 92) that the fish do not eat while spawning, or have very little in their stomachs. In this respect their habits are like those of many other Salmonidæ under like circumstances. If we accept this statement, then the food of the whitefish, except during the spring migration, is obtained within the depth range indicated above. During nine months of the year they are on this range; during June and July in southern latitudes and probably for a corresponding period in more northern latitudes they are engaged in the so-called spring migration; during one month (November in southern latitudes) they are engaged in the spawning or fall migration and during this time they do not feed or feed very little. The existence of the species therefore depends on the utilization of the range referred to. The capacity of any of the Great Lakes to produce whitefish must depend on the extent of this range, assuming the existence of suitable spawning grounds. If we accept Milner's statement (1874, p. 61–62) that young whitefish of less than 1¼ pounds weight are found in water from 20 to 45 feet deep and thereafter enter deep water, the above proposition still stands essentially unmodified, for the production of commercial whitefish or breeding whitefish would still be in relation to the area of the range which furnishes them with food during nine months in the year. These areas I shall refer to hereafter as whitefish areas.

AREAS OF BOTTOM FREQUENTED BY WHITEFISH.

In the accompanying maps (fig. 1 to 5) we have attempted to indicate the extent of the whitefish areas for each of the Great Lakes. These are the areas within which the fishermen find the whitefish when carrying on commercial fishing operations at other times than during the fall and spring migrations. They are the areas over which it is, or has been, profitable to fish, and outside of which the whitefish is found in relatively small numbers. The maps have been made by tracing the appropriate fathom lines on the United States engineer charts of the Great Lakes. They are sufficiently explained in the legends

attached to them. In the following table we have given the whitefish areas for each of the Great Lakes together with the extent in square miles of the lakes themselves. These whitefish areas have been obtained by measuring with a planimeter the areas plotted on the maps. The lake areas are taken from H. M. Smith, 1894.

AREA OF EACH OF THE GREAT LAKES, WHITEFISH AREA OF EACH, AND PERCENTAGE OF WHITEFISH AREA.

	Total area.	Whitefish area.	Percentage of whitefish area.
	Square miles.	*Square miles.*	
Lake Superior	32,000	7,400	23
Lake Michigan	22,000	2,600	12
Lake Huron	21,000	9,400	45
Lake Erie	9,500	4,100	43
Lake Ontario	6,500	2,200	34
Total	91,000	25,700	28

It is to be noted that the area occupied by the true whitefish is relatively least in Lake Michigan, where it forms but 12 per cent of the lake area. Lake Erie comes next with a whitefish area 14 per cent of its total area, if the eastern part of the lake only is taken, but if the western platform of Lake Erie be included over depths of 12 to 30 fathoms, its whitefish area is raised to 4,100 square miles, or 43 per cent of that whole area. Whitefish are taken on those parts of the platform of suitable depth, but in relatively small numbers.

MIGRATIONS.

The whitefish do not wander about at random in these areas, so that the fish of one lake pass into another lake, or those of one part of a lake to a distant part of the same lake. On the other hand, such evidence as we have indicates that the whitefish, like other fish, are during the greater part of the year local in their habits. Their migrations during the breeding season have been already sufficiently referred to, so that we need consider here only the wanderings of the fish during the rest of the year. In general it may be said that the wanderings of fish are by no means fortuitous and, except in the breeding season, are of limited extent. This subject is discussed at some length by Professor Prince (1907) and need not detain us further here. The relative local habits of the nonmigrating herring in England, of the shad in this country, and of the salmon are now well understood. It is well known to fishermen and to dealers who handle whitefish that the fish of different lakes are so unlike that one who is accustomed to them can readily distinguish them. Each lake has its own race and these races do not intermingle by running from lake to lake.

LOCAL HABITS OF WHITEFISH.

Not only does each lake have its race of whitefish, but there are reasons for the belief that parts of lakes are inhabited by races peculiar to them. On this point Milner (1874, p. 47) has the following to say:

> The presence of large whitefish in numbers in certain localities on the north shore of Lake Michigan, of a size that are never taken at other parts of the lake, would indicate a local habit, with no disposition to range through long distances.
>
> Another observation, sustaining the probability of this, is the fact that there are many localities on the lakes where the pound nets, a few years ago, found prosperous fishing, and in the first few years took the whitefish in great abundance, but found afterwards a decrease from year to year until the locality was abandoned, while 50 miles away the business continued successful.
>
> * * * * * * *
>
> The fact that certain types of whitefish are peculiar to certain localities, as the north shore of Lake Michigan, the Sault Ste. Marie Rapids, Bachewauna Bay on Lake Superior, indicates a local habit through many generations until certain characters of a race have become established. The same fact has been stated for the shad on the Atlantic coast.
>
> Some observations made in 1871 perhaps indicate the opposite of all the foregoing statements.
>
> In the early part of the season there had been a few fish caught on the west shore of Lake Michigan between Chicago and the Door Islands. South of Chicago, at the mouth of the Calumet River, the run of whitefish was in excess of anything had for years. But about the 15th of June the schools of fish left Calumet, and a few days later there was a decided improvement in the catch at Evanston. About June 22 the lifts at Waukegan began to be heavier than they had been before. During the first week of July the fishing was observed to improve at Milwaukee, Manitowoc, Baileys Harbor, and, a little later, at the Door Islands.
>
> The coincidence in dates rather indicates that the same schools of fish that clogged the nets at Calumet during six or seven weeks had ranged northward along 260 miles of coast. Still the effect upon the fishing would have been the same if it had been the migrations of schools of fish from deep water at these points in to the shore.

The explanation here offered by Milner, that the phenomenon described in the paragraph is indeed due to the inshore migration of local groups of whitefish beginning at the southern end of the lake and proceeding northward on the west shore, is most probable and is in harmony with the other facts which he cites, as well as with what we now know of local races in other species of fish.

We are concerned here only with those movements of the whitefish which take place out of the spawning season, yet it may not be without interest to cite further from Milner to show that even during the spawning run the movements of the fish are more local than would be thought. He says:

> It is a singular fact that the whitefish are not known to descend from Lake Huron into the St. Clair River. This is established by abundant evidence from continued fishing at Fort Gratiot, where Mr. Clark, between the years 1830 and 1842, took large quantities of the wall-eyed pike, *Stizostedion americana*, taking frequently 1,000 barrels a year. The catch of whitefish amounted to an occasional supply for his own table, except after long continued storms from the northward, when the fish sometimes entered

the river in schools. They were never found in this portion of the river in the spawning season.

The same fact is claimed by the Indians in the Sault Ste. Marie River, that the whitefishes of the lake above never descend the rapids, while the whitefishes of the river, it is also asserted, never ascend to Lake Superior. There is not as good evidence for the truth in this locality as at Fort Gratiot; still it may be the case.

The evidence collected by Rathbun and Wakeham points also to the local habit of the whitefish of Lake Ontario. They say (p. 60):

> There does not seem to have been any regular migration of these fish lengthwise of the lake. They occurred along a narrow border of the lake and simply moved to feeding grounds in the spring and to spawning grounds in the fall wherever the shoal water was suitable. There they were most abundant, and on these areas we still find the remnant of them.

Again they say of Lake Huron:

> The movements of the whitefish in Lake Huron are, in general, less definite than in Lake Erie, being confined to shoreward migrations in the spring and fall. These migrations appear to be accompanied by no extensive progress alongshore, except at Detour, where the spring run is said to have a general easterly direction, appearing first near Detour and then passing down the North Channel into Georgian Bay.

It would be easy to compile evidence from the statistical returns of the Michigan fish commission to show the local habit of the whitefish, from the fact that fisheries have often been depleted in one locality while remaining profitable in other localities 25 to 50 miles distant, but the facts already cited seem to be sufficient for the purpose.

WHITEFISH AREAS OF GREAT LAKES.

An examination of the whitefish areas as platted on the accompanying maps tends to strengthen this view of the local habit of the whitefish. In Lakes Superior, Ontario, and Michigan we see this area stretching in a relatively narrow zone along the whole shore. This zone incloses a central area of deeper water which separates the whitefish area of one side of the lake from that of the other side and is probably never crossed by these fish. Within it occur the blackfins and longjaws. In Lake Huron we see a similar condition of affairs for the main lake, but in Georgian Bay we find the greater part of the area taken up by whitefish grounds. Here the deep water is not central in the whitefish area but is displaced toward the southwest so as to leave the marginal whitefish area very narrow on one side of the lake and very broad on the other side. In the North Channel of Lake Huron a continuous whitefish area occupies its center uninterrupted by a deeper middle water. In this lake the reef which cuts obliquely across the main lake is said not to harbor whitefish in commercial quantities and not to afford them spawning ground. It is therefore not included in the whitefish area, although of suitable depth, and its extent is indicated on the map in outline only.

FIG. 1.—LAKE SUPERIOR.

Whitefish area (shown in black), 10 to 50 fathoms. (Reduced from U. S. Hydrographic Office chart no. 1474. Scale: 1 in. = about 44 miles.)

FIG. 2.—LAKE MICHIGAN.

Whitefish area (shown in black), 12 to 20 fathoms and (to dotted line) 20 to 40 fathoms. (Reduced from U. S. Engineer chart. Scale: 1 in. = about 41 miles.)

In Lake Erie the whitefish area is divided into two portions—a western, which occupies the central portion of the lake west of Conneaut and is not interrupted by deeper middle water, and an eastern, which lies eastward of Conneaut and contains a small central middle portion of deeper water. The two portions are connected by a narrow neck at their southern borders. So far as I can learn the whitefish appear to confine themselves during most of the year to the eastern portion of this area, though for what reason is unknown.

FIG. 3.—LAKE HURON.

Whitefish area (shown in black), 10 to 35 fathoms. (Reduced from U. S. Hydrographic Office chart no. 1478. Scale: 1 in. = about 46.8 miles.)

More careful examination of the maps shows that while the whitefish area is continuous in most of the lakes about the whole border, this is not the case in Lake Michigan. Just south of Little Point Au Sable the area is nearly interrupted, and to the north of this it breaks up into numerous small areas which are either detached from one another or nearly so. Of course if the deeper

limit of the whitefish area had been taken as 30 or 40 fathoms the area would become more nearly continuous. In selecting 20 fathoms as the deeper limit of this area in Lake Michigan I have been guided by the statements of Ward (1896), which seem to merit every confidence. On the map of Lake Michigan I have, however, indicated also the 40-fathom limit by a dotted line. The area between the dotted line and the black area shows the region which contains longjaws in commercial quantities, especially along its shoreward margin. The blackfins rarely enter this area, but remain in deeper water. This area is one into which the whitefish doubtless wander to a greater or less extent, but according to the statements of Professor Ward, not in commercial quantities. The map shows that if this area between the dotted line and the black area be included within the range of the true whitefish, that range is even then not con-

FIG. 4.—LAKE ERIE.

Whitefish area (shown in black), 12 to 30 fathoms. (Reduced from U. S. Hydrographic Office chart no. 1477. Scale: 1 in. = about 50 miles.)

tinuous along the eastern shore of Lake Michigan. It is interrupted north of Big Point Au Sable and in a number of places still farther north. In handling the statistics of these fisheries we have attempted to study discreet areas within individual lakes. The extent of these is indicated in another place.

Within the whole whitefish area of the Great Lakes the production of marketable whitefish has greatly declined since the first statistics were taken in 1880. This is evident from a glance at the table given by Alexander (1905, p. 650), where is given the whitefish production for each lake for the years 1880, 1885, 1890, 1893, 1899, 1903. As to the cause of this decrease there is no difference of opinion among those who have investigated it. Investigators from Milner in 1871 to Rathbun and Wakeham in 1893 to 1896 have reached but one conclusion, namely, that the decrease is due to overfishing. Ward (1896)

strengthens this conclusion when he finds that on grounds where whitefish were formerly abundant, but on which they are now scarce, the food of the whitefish still exists in apparent abundance. The following quotations from Professor Ward are of interest in this connection. He says (p. 24):

We are thus forced to the conclusion that the decrease in the whitefish supply can have no other cause than overcatching. This is not the place to discuss good and bad methods of fishing or remedies for the trouble. Our investigations point unmistakably to the cause of the depletion in the whitefish supply; it is the removal from the lakes of a larger number than can be replaced by natural processes and than has been successfully returned by artificial hatching.

FIG. 5.—LAKE ONTARIO.

Whitefish area (shown in black), 10 to 20 fathoms. (Reduced from U. S. Hydrographic Office chart no. 1477. Scale: 1 in. = about 48 miles.)

Again (p. 67) he says:

There is a plentiful supply of whitefish food on the old fishing grounds. No reason can be assigned for the diminution in the supply of whitefish save overcatching.

I can only concur in these opinions, which are supported by incontrovertible evidence collected by many investigators.

EFFECT OF PROPAGATION UPON WHITEFISH PRODUCTION IN THE GREAT LAKES.

ANNUAL CATCH AND PLANT IN MICHIGAN AND CANADIAN WATERS.

In tables 1 to 10 are arranged certain data concerning the annual catch and annual plant of whitefish in Michigan and Canadian waters of the Great Lakes for the fifteen years 1892 to 1906, inclusive. The catch of whitefish

in Michigan has been taken directly from the original records on file in the office of the Michigan Fish Commission, while the catch in Canadian waters has been kindly furnished by the Department of Marine and Fisheries of the Dominion of Canada. The plants of whitefish that have been made in Canadian and Michigan waters have been taken from the reports of the Department of Marine and Fisheries of the Dominion of Canada, from the reports of the United States Fish Commission, and from the reports of the Michigan Fish Commission. In the column headed "Total gill and pound nets in fathoms" are given in fathoms the added lengths of gill nets and of pound-net leaders. The lengths of gill nets are given in fathoms in the official records. The lengths of pound nets are also given in fathoms in the Michigan records, but in the Canadian records the number only of pound nets is given, without their lengths. In order to obtain the lengths of pound nets used in Canadian waters I have averaged the lengths of approximately 1,000 Michigan pound nets selected at random, and have multiplied the number of Canadian pound nets in each year by this average value. In the last column of the tables 1 to 10 are given the values obtained by dividing the total catch of whitefish in pounds by the lengths of gill nets and pound nets in fathoms. The figures in this column therefore express in pounds for each year the catch of whitefish per fathom of nets used. It should be understood, however, that these tables give the total lengths of all gill and pounds nets used in the waters referred to whether the nets actually took whitefish or not. I have found it impossible to separate the nets which were set for whitefish or which took whitefish from those which were set for other fish, and I have been therefore under the necessity of taking the total lengths of all gill and pound nets used in the waters under discussion. As will appear in the discussion which follows, I attach relatively little importance to this part of the table.

I have already alluded to the difficulty encountered in obtaining statistics which deal with whitefish only and which do not include at the same time longjaws, bluefins, or menominees. We are assured by the superintendent of the Michigan Fish Commission that the data for the catch of whitefish in Michigan waters contained in tables 1 to 10 include true whitefish (*Coregonus clupeiformis*) only, and I am assured that the statistics of the catch of whitefish collected by the authorities of the Dominion of Canada and included in tables 1 to 10 refer to the true whitefish only and do not include bluefins or longjaws. These tables therefore have a peculiar interest in being, so far as I know, the only tables published of the catch of true whitefish for a continuous period of fifteen years.

TABLE 1.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN CANADIAN WATERS OF LAKE SUPERIOR FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892		1,800,640	78,820	22.84
1893		927,700	119,670	7.82
1894		1,087,733	162,650	6.68
1895		947,895	206,760	4.58
1896		850,600	189,640	4.43
1897		726,675	245,100	2.97
1898		663,230	215,380	2.61
1899	[a] 1,500,000	623,229	387,490	1.51
1900	[a] 2,000,000	461,546	224,980	2.05
1901		482,760	146,425	3.29
1902		398,943	133,450	2.98
1903		563,950	182,445	3.09
1904		436,520	237,595	1.83
1905		491,980	229,300	2.10
1906		420,700	247,400	1.70

[a] Planted by United States Fish Commission.

TABLE 2.—ANNUAL CATCH AND PLANT OF WHITEFISH, AND TOTAL LENGTH OF NETS IN USE IN MICHIGAN WATERS OF LAKE SUPERIOR (EXCLUSIVE OF ISLE ROYAL) FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	[a] 2,000,000 8,500,000	2,754,200	542,781	5.07
1893	[a] 11,000,000 8,000,000	2,423,600	596,220	4.06
1894	[a] 14,000,000 8,885,000	2,385,100	803,395	2.96
1895	[a] 13,350,000 28,900,000	1,618,220	705,306	2.39
1896	[a] 16,250,000 1,000,000	1,401,900	869,006	1.61
1897	[a] 8,000,000 11,990,000	1,329,284	744,809	1.78
1898	[a] 3,000,000 2,000,000	1,223,940	685,620	1.78
1899	[a] 4,000,000 5,200,000	1,128,650	724,271	1.55
1900	22,700,000	1,106,050	684,843	1.64
1901	[a] 12,800,000 20,800,000	1,056,325	911,995	1.15
1902	[a] 18,800,000 39,800,000	1,615,775	1,089,840	1.04
1903	[a] 16,600,000 13,300,000	1,345,000	1,060,990	1.26
1904	[a] 9,075,000	979,000	1,407,400	.69
1905	[a] 10,576,000 21,200,000	1,061,150	1,265,646	.83
1906	[a] 31,460,000 21,544,000	964,000	1,332,542	.72

[a] Planted by Wisconsin and United States Fish Commissions in Chequamegon Bay; adjacent to Michigan waters not included in calculations of table.

TABLE 3.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN MICHIGAN WATERS OF THE NORTH SHORE OF LAKE MICHIGAN FROM WISCONSIN BORDER TO THE STRAIT OF MACKINAW FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.[a]

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	8,000,000	1,093,183	398,299	2.49
1893	8,000,000	952,050	391,682	2.43
1894	8,500,000	576,300	460,097	1.25
1895	4,000,000	461,661	295,502	1.56
1896	7,386,000	870,000	390,099	2.23
1897	19,540,000	1,346,120	553,672	2.63
1898		1,179,350	495,426	2.37
1899	6,000,000	781,080	543,710	1.43
1900	4,000,000	601,450	465,700	1.28
1901	[b] 6,000,000	799,800	539,819	1.48
1902	2,000,000 [b] 12,000,000	1,036,950	703,020	1.47
1903	11,000,000	1,131,600	778,716	1.40
1904	3,000,000	1,079,000	867,310	1.24
1905	6,000,000	1,113,700	771,617	1.44
1906	7,000,000	1,563,200	1,088,429	1.43

[a] Strait of Mackinaw not included.

[b] Planted from Mackinaw City in waters adjacent to those of the north shore.

TABLE 4.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN MICHIGAN WATERS OF LAKE MICHIGAN FROM LITTLE POINT AU SABLE TO THE INDIANA BORDER FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.[a]

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	8,500,000	30,615	497,371	0.061
1893	6,000,000	47,100	600,828	.078
1894	14,500,000	88,875	424,482	.209
1895	2,000,000	50,650	368,447	.136
1896	2,000,000	39,850	390,638	.102
1897	6,000,000	32,783	237,662	.138
1898		24,150	261,736	.082
1899		27,500	306,860	.078
1900		27,850	506,921	.054
1901	[b] 4,000,000	29,350	560,291	.052
1902		26,900	624,520	.043
1903		38,400	598,690	.064
1904		69,200	691,260	.100
1905		185,200	858,691	.215
1906		337,600	832,051	.405

[a] From the United States Fish Commission Report for 1887, p. 84, we find that the catch in this area in 1885 was 538,817 pounds.

[b] At Michigan City, Ind., very near the Michigan boundary line.

TABLE 5.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN MICHIGAN WATERS OF LAKE MICHIGAN FROM MANISTEE TO FRANKFORT [a] FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch in pounds per net-fathom.
1892	8,500,000	222,600	162,706	1.36
1893	6,000,000	155,000	151,090	1.02
1894	11,000,000	72,700	138,483	5.36
1895	8,000,000	78,150	150,447	.517
1896	6,000,000	109,800	181,966	.60
1897	6,500,000	145,200	80,583	1.80
1898	----------	155,200	138,552	1.12
1899	----------	140,750	134,490	1.04
1900	16,000,000	161,200	187,551	.86
1901	----------	155,200	153,780	1.00
1902	----------	201,000	195,472	1.33
1903	----------	172,600	210,240	.82
1904	----------	226,000	249,840	.90
1905	----------	190,600	296,753	.63
1906	----------	205,000	262,020	.72

[a] From United States Fish Commission Report for 1887, p. 84, we find the catch at Frankfort alone for 1885 was 885,504 pounds.

TABLE 6.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN MICHIGAN WATERS OF LAKE HURON FROM MACKINAW CITY TO PORT HURON FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	21,750,000	555,350	588,019	0.94
1893	16,640,000	535,750	528,566	1.01
1894	16,050,000	396,350	505,497	.78
1895	15,500,000	357,317	657,255	.54
1896	19,850,000	659,234	347,799	1.79
1897	23,440,000	525,860	435,345	1.20
1898	5,600,000	387,740	537,704	.72
1899	12,000,000	482,980	622,686	.77
1900	34,200,000	403,020	766,278	.52
1901	26,000,000	600,620	873,896	.68
1902	42,000,000	639,600	843,691	.77
1903	30,000,000	722,560	1,050,667	.68
1904	30,000,000	618,960	1,056,170	.58
1905	25,000,000	329,260	1,235,910	.26
1906	20,000,000	265,320	772,098	.34

TABLE 7.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN CANADIAN WATERS OF LAKE HURON, INCLUDING NORTH CHANNEL, FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.[a]

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	[b] 3,000,000	2,639,156	391,067	6.74
1893	3,000,000	2,278,300	679,395	3.35
1894	3,000,000	1,504,436	741,135	2.03
1895	3,000,000	771,475	535,670	1.44
1896	3,000,000	1,091,950	598,380	1.82
1897	3,000,000	740,041	240,525	3.08
1898	3,300,000	904,180	683,480	1.32
1899	4,000,000	864,240	335,772	2.57
1900	4,000,000	1,255,075	554,045	2.26
1901	4,300,000	935,003	471,732	1.97
1902	5,000,000	1,181,268	868,137	1.36
1903	4,000,000	831,610	659,835	1.26
1904	3,000,000	1,578,790	650,630	2.42
1905	4,000,000	739,410	824,610	.89
1906	4,000,000	922,800	709,440	1.32

[a] Exclusive of Georgian Bay.

[b] In the absence of exact information for the years 1892 and 1893 the plants of these years are assumed to have been the same as in the years immediately following and are so entered here.

TABLE 8.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN THE WATERS OF GEORGIAN BAY FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom
1892		3,635,700	40,000	90.89
1893		1,601,000	773,500	2.06
1894		1,199,300	581,250	2.06
1895		642,030	1,071,000	.59
1896		584,750	620,650	.90
1897		311,995	528,300	.59
1898	600,000	340,750	653,400	.52
1899	300,000	822,520	615,071	1.33
1900	550,000	274,180	419,450	.65
1901	600,000	501,842	326,950	1.53
1902		465,590	361,030	1.28
1903		467,080	844,100	.55
1904		470,670	441,650	1.06
1905		333,620	443,550	.75
1906		379,950	486,190	.78

TABLE 9.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN CANADIAN WATERS OF LAKE ERIE FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.[a]	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	[b] 34,500,000	311,950	32,850	9.49
1893	[b] 58,000,000	256,240	49,540	5.17
1894	37,000,000	153,033	73,660	2.08
1895	61,000,000	148,010	84,410	1.75
1896	49,000,000	126,300	86,990	1.44
1897	60,000,000	270,290	92,360	2.92
1898	59,000,000	245,365	90,480	2.71
1899	60,000,000	431,022	107,910	3.99
1900	64,000,000	401,425	191,915	2.09
1901	60,000,000	523,366	141,460	3.69
1902	77,000,000	449,886	133,411	3.37
1903	62,000,000	303,280	169,250	1.79
1904	44,000,000	360,800	228,535	1.57
1905	72,000,000	304,400	236,200	1.29
1906	55,000,000	359,100	268,480	1.33

[a] Includes Detroit River.

[b] In the absence of exact information for the years 1892 and 1893 the plants of these years are assumed to have been the same for Lake Huron, Georgian Bay, and Lake Ontario as in the years immediately following, and the remaining plant was assigned to Lake Erie.

TABLE 10.—ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN CANADIAN WATERS OF LAKE ONTARIO FOR EACH OF THE YEARS 1892 TO 1906, INCLUSIVE.

Years.	Plant of fry.	Catch, in pounds.	Total gill and pound nets, in fathoms.	Catch, in pounds per net-fathom.
1892	[a] 3,800,000	489,900	144,775	3.38
1893	[a] 3,800,000	369,570	126,730	2.91
1894	3,800,400	299,930	158,705	1.88
1895	4,800,000	126,650	173,645	.72
1896	4,800,000	170,350	255,100	.66
1897	4,800,000	292,460	273,670	1.06
1898	4,900,000	410,420	233,810	1.75
1899	5,050,000	259,815	168,155	1.54
1900	4,800,000	129,126	231,405	.55
1901	4,550,000	133,192	156,480	.85
1902	3,000,000	77,071	153,920	.50
1903	3,000,000	96,980	186,352	.51
1904	4,000,000	190,650	221,512	.86
1905	4,000,000	472,770	249,820	1.89
1906	4,000,000	354,000	258,792	1.37

[a] In the absence of exact information for the plants in 1892 and 1893 it has been assumed to be the same from each hatchery as in the years immediately following, the total plant remaining constant, and is so set down here.

An examination of any one of these tables shows great fluctuation in the annual catch of whitefish, which may increase or diminish nearly 50 per cent between one season and the next, and in some cases varies 300 per cent between successive years. The cause of these annual fluctuations is to be found, no doubt, in part in the weather conditions, which permit almost continuous fishing in one season while they may greatly interfere with the fishing in the succeeding season. But these fluctuations may also be due in part to some feature of the habits of the whitefish themselves which we do not at all understand. It would be possible, by terminating almost any one of these tables at a suitable point, to convey the impression that there has been a very great falling off in the catch of whitefish in any one of the lakes. Thus if table 2 should terminate with the year 1902 it would show apparently a steady decrease in the catch of whitefish in the Canadian waters of Lake Superior and a like impression may be gained with respect to any other one of the lakes by terminating the table at the appropriate year.

DISCUSSION OF AVERAGE CATCH AND PLANT FOR CERTAIN AREAS.

It is evident from an examination of tables 1 to 10 that no conclusion of value is to be reached by comparing the whitefish production of the Great Lakes for individual years. The annual fluctuations, whatever may be their cause, vitiate any conclusions that may be drawn from such comparisons. It is further evident that any comparisons should take into account the relative whitefish areas of the lakes compared, and should consider both the catch and the plant with reference to these areas.

In tables 11 to 18 an attempt has been made to avoid the errors just mentioned by comparing the average catch for the three five-year periods from 1892 to 1906, inclusive. In the first column is entered the average annual catch in pounds for each of these five-year periods. In the second column is given the average catch per square mile of whitefish area, while in the third column is stated the average catch per fathom of net used. In the same tables are given the plants of whitefish; the annual average for each five-year period, the average per square mile of whitefish area, and the average per pound of whitefish caught. The same tables give the average annual number of fathoms of nets used for each period and the fathoms of nets per square mile. By nets is to be here again understood all nets used in the areas in question, not merely nets in which whitefish were taken. Not much value can therefore be attached to that part of the table which deals with nets.

Canadian and Michigan waters of Lake Superior.—In table 11 the data for the Canadian and Michigan waters of Lake Superior are brought together for comparison. The Michigan whitefish area of 2,400 square miles extends from the St. Marys River westward to the Wisconsin boundary line, as indicated on the map of Lake Superior. It does not include Isle Royal for the reason that

this offers an isolated whitefish area unconnected with that to the north or south of it, and for the further reason that the statistical returns from this remote area show such extraordinary fluctuations in catch, plant, and amount of nets used as to make them of little value. The Canadian side of Lake Superior shows a whitefish area of 3,600 square miles, stretching from the St. Marys River westward to the Minnesota boundary. On the Michigan shore there has been a very large annual plant of whitefish fry, averaging 11,000,000 in the first period, 22,000,000 in the second period, and 15,000,000 in the third period. This amounts to about 5,000 fry planted annually per square mile of area during the first period, 9,000 during the second period, and 6,000 during the third period. For each pound of fish taken out there has been planted during the first period an annual average of 5 fry, during the second period an annual average of about 19, and during the third period an annual average of more than 12. These values would be greatly increased if they were made to include the Wisconsin plants, which are indicated by the footnote in table 2, but not included in the calculations in table 11.

TABLE 11.—COMPARISON OF THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN MICHIGAN AND CANADIAN WATERS OF LAKE SUPERIOR FOR THE THREE FIVE-YEAR PERIODS 1892 TO 1906, INCLUSIVE.[a]

Michigan waters, whitefish area 2,400 square miles.

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	2,117,000	881	3.22	11,057,000	4,607	5.2	703,300	293
1897–1901	1,169,000	487	1.58	21,858,000	9,178	18.8	750,300	312
1902–1906	1,193,000	497	.91	15,268,900	6,362	12.8	1,231,300	513

Canadian waters, whitefish area 3,600 square miles.

1892–1896	1,123,000	312	9.27				151,500	42
1897–1901	591,000	164	2.48	700,000	194	1.2	243,800	67
1902–1906	462,000	128	2.32				206,000	57

[a] Exclusive of Isle Royal.

If we compare the catches over this area for the three periods, we see that while there was a decline of nearly a million pounds in the annual average between the first period and the second, there was a slight increase in the third period as compared with the second. The whitefish production of this area is therefore not decreasing; it is increasing. This increase has been accompanied by a considerable increase in the length of nets used, but as will appear in another place in this paper there seems to be good reason for the belief that an increase in the length of nets used is not sufficient to account for the increase

in the catch under the conditions existing in the Great Lakes. Furthermore, we have no reason to believe that the additional nets were used for whitefish.

If we turn now to the Canadian area of Lake Superior as shown in table 11 we see that there was no plant of whitefish fry during the first and third periods and during the second period a plant averaging but 700,000 annually, 194 per square mile, or but little over one fry per pound of fish. This plant was all made at a single locality—Port Arthur—and during the two years 1899 and 1900. The catch of whitefish in this Canadian area decreased from the first to the second period in about the same proportion as the catch on the American side and it continued to decrease notably in the third period. This decrease took place on the Canadian side while an increase was in progress on the American side, and it took place in spite of the fact that the length of nets in use on the Canadian side was but from one-third to one-fifth that on the American side. During the third period the fishermen on the American side were fishing nearly ten times the length of nets per square mile that their Canadian brothers were permitted to use and were enjoying an increase in the average annual catch of whitefish while the Canadian fishermen were suffering from a decrease in the average annual catch.

Canadian and Michigan waters of Lake Huron.—The data for these waters are given in tables 12 and 13. The Michigan waters are those of the west shore of Lake Huron from Mackinaw City to Port Huron. The Canadian waters are, in table 12, the eastern shore of Lake Huron, including the North Channel, and in table 13 the Georgian Bay. We see that on the Michigan side there has been a plant of from about 18,000,000 fry annually in the first period to nearly 30,000,000 annually in the third period. This is a plant averaging from 5,500 to 9,000 fry per square mile of whitefish area. In other words, from 36 to 58 fry have been placed in these waters for every pound of whitefish taken from them. The catch of whitefish has remained practically constant, but has increased somewhat in the last period as compared to the second. On the Canadian side of Lake Huron there has been a comparatively light plant of whitefish fry in each of the three periods, less than one-sixth that on the Michigan side. The catch of whitefish fell off very much in the second period as compared with the first, but recovered somewhat during the third period. If we compare the Michigan waters of Lake Huron with Georgian Bay (Canadian) we find that in Georgian Bay there has been comparatively little planting of whitefish and this confined to the second period. It averages but 152 fry per square mile of whitefish area and but 1 fry per pound of whitefish caught. The catch of whitefish has fallen off more than two-thirds in the second period as compared with the first and has diminished still further, though slightly, in the third period.

TABLE 12.—COMPARISON OF THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN MICHIGAN AND CANADIAN WATERS OF LAKE HURON FOR THE THREE FIVE-YEAR PERIODS 1892 TO 1906, INCLUSIVE.

Michigan waters, whitefish area 3,200 square miles.[a]

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathoms.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	501,000	158	0.99	17,958,000	5,559	36	525,400	164
1897–1901	480,000	148	.79	20,258,000	6 271	42	847,100	264
1902–1906	515,000	159	.58	29,400,000	9,101	58	991,700	309

Canadian waters, whitefish area 3,000 square miles.[b]

1892–1896	1,657,000	552	3.07	3,000,000	1,000	1.8	589,100	196
1896–1901	940,000	313	2.24	3,720,000	1,240	3.9	457,100	150
1902–1906	1,051,000	350	1.45	4,000,000	1,333	3.8	742,500	244

[a] From Mackinaw City to Port Huron.
[b] North Channel and Lake Huron exclusive of Georgian Bay.

TABLE 13.—SHOWING THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN GEORGIAN BAY WATERS FOR THE THREE FIVE-YEAR PERIODS 1892–1906, INCLUSIVE.

Whitefish area 2,700 square miles.

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	1,535,000	568	19.3				617,300	228
1897–1901	450,000	166	.92	410,000	152	1	508,600	188
1902–1906	423,000	156	.88				515,300	191

We appear to have disclosed in Lakes Superior and Huron a relation between the plant of whitefish fry and the catch of a subsequent period of such a sort that when the plant has been considerable the catch has either been maintained or has increased, while when the plant has been small the catch has usually diminished. There are no statistics available which enable us to compare for long periods the data for the two sides of the same lake, except those for Lakes Superior and Huron, but it will be of interest to compare with these two lakes Lakes Erie and Ontario and parts of Lake Michigan.

Canadian waters of Lake Erie and Lake Ontario.—The only statistics available for continuous periods are those of the Canadian sides of these lakes, but these are of especial interest, because they enable us to compare Canadian waters in which there has been relatively heavy planting of whitefish fry with those in which the plant has been light. The Canadian whitefish areas of Lake Erie,

including both the eastern and western portions, are 2,100 square miles. For each of the five-year periods considered the plant on this area has been enormous—from about 28,000 to about 30,000 fry per square mile of whitefish area, or from 139 to 230 fry per pound of whitefish caught. At the same time the catch has increased, nearly doubling in the second period as compared with the first and then remaining practically constant during the third period.

In Lake Ontario the area of whitefish ground on the Canadian side has been estimated at 1,400 square miles. The plant per square mile has been about one-tenth that in Lake Erie, while the catch has diminished appreciably, though not greatly.

TABLE 14.—SHOWING THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN CANADIAN WATERS OF LAKES ERIE AND ONTARIO FOR THE THREE FIVE-YEAR PERIODS 1892 TO 1906, INCLUSIVE.

Lake Erie, whitefish area 2,100 square miles.

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	199,000	94	3.98	45,900,000	21,857	230	65,500	31
1897–1901	354,000	168	3.08	60,500,000	28,857	171	124,800	59
1902–1906	355,000	169	1.87	62,000,000	29,523	175	207,200	98

Lake Ontario, whitefish area 1,400 square miles.

1892–1896	291,000	207	1.91	4,200,000	3,000	14	171,800	122
1897–1901	245,000	175	1.15	4,820,000	3,443	19	212,700	152
1902–1906	238,000	170	1.02	3,600,000	2,571	15	214,000	153

Unfortunately, we have no statistics of the catch of whitefish for the American side of either Lake Erie or Lake Ontario for any continuous period of years, so we are unable to make comparisons with the Canadian side. In table 22 there is shown the annual catch and plant in the whole of these lakes for the years 1899 and 1903, the only years for which statistics are available for the catch in which the true whitefish is separated from related forms in American waters.

The statistics of the catch need not detain us here, but those of the plant are interesting since they show that for the first of these years the total plant in Lake Erie from all sources, Canadian and American, was about 197,000,000 fry, while the plant in Lake Ontario for the same year was less than one-tenth as great. In 1903 the plant in Lake Erie was still nearly four times that in Lake Ontario. Not only is there this very great difference in the plant in these two lakes, a difference which exists in other years also, but it is extremely probable that the Lake Erie plant on the American side affects the catch on the Canadian side. The whitefish area of Lake Erie is practically continuous for the eastern

part of the lake and continuous in a nearly separate area for the western part of the lake. Any plants therefore on either side of the lake might well produce fish that would make their way to the opposite shore. In interpreting table 14 it is therefore to be taken into account that the plant affecting the Canadian catch is probably much greater than that entered in the table and would probably be more correctly represented by values similar to those entered in table 18. On the other hand, both the actual and the effective plants in Lake Ontario are very much less than in Lake Erie. We see thus in the Canadian waters of Lake Erie a very great increase in the production of whitefish correlated with very large plants of fry. In Lake Ontario we see a reduction in whitefish production correlated with a moderate plant of fry, a plant which is, for unit area, about half that of the Michigan waters of Lake Superior for the same periods.

Restricted areas of Lake Michigan.—In tables 15 and 16 there are brought together the data of catch, plant, and nets used in certain restricted areas of Lake Michigan. The data for the catch are all taken from the records of the Michigan Fish Commission, while those of the plant are published in the reports of the Michigan Fish Commission and the United States Bureau of Fisheries.

The areas selected are as follows:

(1) An area designated in table 15 as the "north shore" of Lake Michigan comprises the whitefish grounds from the Strait of Mackinaw westward to the Michigan-Wisconsin boundary in Lake Michigan. The eastern limit of this area is therefore well defined, but at its western limit it is broadly continuous with the waters of the State of Wisconsin. It contains 800 square miles, as shown on the map of Lake Michigan. The plant of whitefish fry in this area in the three successive five-year periods has been from 7,000 to 9,000 per square mile and from 5 to 9 per pound of fish caught. At the same time the catch in round numbers has been, in successive periods, 800,000, 950,000, 1,200,000. Here we have again a greatly increased catch correlated with a large and intensive plant.

(2) An area designated in the table as the "southeast" Michigan shore, comprises the whitefish grounds from Little Point Au Sable south to the Indiana-Michigan boundary. At its northern limit this area is nearly separated from the whitefish area to the north of it, but at its southern end it is broadly continuous with the Indiana waters of Lake Michigan. These waters, have, however, for a long time yielded very few whitefish, so that the area in question may be regarded as practically limited by barren waters at its lower end. Its area is 300 square miles. For the first period this area received a plant of 22,000 fry annually per square mile, an average of 125 per pound of fish caught. In the second period the plant was reduced to an average of about 7,000 annually, or 68 per pound of fish caught. The latter averages are based on a total which includes a plant of 4,000,000 made in 1901 at Michigan City, Ind., just beyond the Michigan border. If this plant be excluded the figures for the second period are reduced 40 per cent. Here again we have a very large increase in the catch

correlated with a very large and intensive plant. The catch of the third period exceeds that of the second more than fivefold. The number of whitefish appears, however, not to have increased in the period immediately following the greatest activity in planting, for while the plant of the first period was very great the catch of the succeeding period showed a decrease to little more than one-half that of the preceding period. This is possibly to be explained by the fact that in the nineties this area was considered to be nearly depleted of whitefish, and fishing for them was prosecuted with much less vigor than before. The number of fathoms of nets in use fell off, and it is probable that the nets set for whitefish fell off still more. It seems, therefore, probable that the whitefish may have begun to increase during the second period, but that this fact was not known to the fishermen until well into the third period. In other words, it is probable that the catch did not increase until some years after the whitefish themselves had increased. A glance at table 4 shows that this increase in the catch became noticeable in 1903.

TABLE 15.—SHOWING THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN MICHIGAN WATERS OF LAKE MICHIGAN (THE NORTH SHORE AND THE SOUTHEAST SHORE) FOR THE THREE FIVE-YEAR PERIODS 1892 TO 1906, INCLUSIVE.

North shore, whitefish area 800 square miles.[a]

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	791,000	988	1.99	7,177,000	8,971	9	387,100	459
1897–1901	942,000	1,177	1.83	5,908,000	7,385	6	519,600	649
1902–1906	1,183,000	1,477	1.39	5,800,000	7,250	5	841,800	1,052

Southeast Michigan shore, whitefish area 300 square miles.[b]

1892–1896	52,000	170	0.117	6,600,000	22,000	125	456,300	1,521
1897–1901	29,000	96	.081	2,000,000	6,666	68	374,700	1,249
1902–1906	132,000	440	.165				721,000	2,403

[a] North shore, from the Wisconsin border to the Strait of Mackinaw (excluding the Strait of Mackinaw).
[b] Southeast shore, from Little Point Au Sable south to the Indiana border.

(3) The Manistee-Frankfort area is an apparently isolated area of 90 square miles lying off the cities of those names. The data for this area are shown in table 16 (for annual data see table 5). Here we have a plant of fry which for the area is enormous, nearly 90,000 per square mile in the first period and nearly 60,000 per square mile during the second period. There was no plant during the third period. The catch has risen during the fifteen years from 128,000 pounds per square mile in the first period to 152,000 in the second and 211,000 in the third. Here again we have a correlation of heavy planting with increased yield of fish.

TABLE 16.—SHOWING THE AVERAGE CATCHES AND PLANTS OF WHITEFISH IN MICHIGAN WATERS OF LAKE MICHIGAN FROM MANISTEE TO FRANKFORT, INCLUSIVE, FOR THE THREE FIVE-YEAR PERIODS 1892 TO 1906, INCLUSIVE.

Whitefish area, 90 square miles.

Years.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1892–1896	128,000	1,422	0.80	7,900,000	87,777	62	156,900	1,743
1897–1901	152,000	1,688	1.16	5,300,000	58,888	35	138,900	1,543
1902–1906	211,000	2,344	.88	----------	----------	----------	242,900	2,498

PRODUCTION COMPARED WITH INTENSITY OF PLANT.

The data that have been presented seem to show that wherever, whether in American or Canadian waters, there has been a large plant of whitefish fry per unit area (20,000 in at least one period) this is correlated with a considerably increased average yield of adult fish per unit area in one or another period (Manistee and Frankfort and southeast Michigan areas of Lake Michigan, Canadian waters of Lake Erie); wherever there has been a moderate plant of fry per unit area (5,000 to 10,000 per square mile) this is correlated with a moderately increased yield of adult fish per unit area in one or another period or by a practically stationary yield (north shore of Lake Michigan, Michigan waters of Lake Huron from Port Huron to Mackinaw City, Michigan waters of Lake Superior); wherever there has been a small plant of whitefish fry per unit area (less than about 3,500) or no plant, this is correlated with a diminished yield of adult fish per unit area (Canadian waters of Lakes Superior, Ontario, and Huron and Georgian Bay, except for a slight increase in Lake Huron from second to third period).

CONCLUSIONS AS TO EFFECT OF PROPAGATION.

The result reached in this section is expressed in another form in tables 17 and 17*a*, in which the whitefish areas already discussed are arranged in the order of the intensity of the plant made on them per unit area. Arranged in this way the series falls into three groups. The first, including the Manistee and Frankfort area, the southeast Michigan shore, and the Canadian waters of Lake Erie, comprises areas which have in at least one of the three periods received plants of at least 20,000 per square mile. The increase or decrease in the catch of each area of this group is shown for the second and third periods in the right-hand column in percentages of the catch compared with that of the preceding period. Positive values indicate an increase in catch, negative values a decrease. These percentages are of considerable amount and are positive in every case but one; the catch for the southeast Michigan shore is less for the second period than for the first (43 per cent), but it increases again enormously in passing from the second period to the third (350 per cent).

The second group of areas as arranged in table 17 includes the north shore of Lake Michigan, the west shore of Lake Huron from Mackinaw City to Port Huron, and the south shore (Michigan waters) of Lake Superior. In this group the intensity of the plant of whitefish fry per square mile varies from about 5,000 to about 10,000. But two negative percentages appear in the table opposite these areas; these are both in passing from the first to the second period, and both are reversed in passing from the second to the third period, where they become positive.

The third group of areas includes the north shore of Lake Ontario, the east or Canadian shore of Lake Huron, the north shore of Lake Superior, and Georgian Bay. The plant per unit area has been largest in Lake Ontario, but has not there exceeded 3,600 per square mile. It diminishes progressively in the order in which the areas are named above, and becomes practically nothing in Lake Superior and Georgian Bay. The percentage column shows no positive value, while the sum of the negative values is very large.

TABLE 17.—SHOWING THE RELATIONSHIP OF THE AVERAGE PLANT OF WHITEFISH FRY PER UNIT AREA IN CERTAIN WATERS OF THE GREAT LAKES, TO THE AVERAGE CATCH IN THE SAME UNIT AREA FOR THREE FIVE-YEAR PERIODS.

	Whitefish areas.	Plant per square mile (to nearest 100).	Catch, pounds, per square mile (to nearest 10).	Per cent of increase (plus values) or decrease (minus values) of each period over the preceding period.
	1892–1896.			
1	Manistee and Frankfort	87,800	1,420	
1	Lake Erie (Canadian)	21,900	94	
1	Lake Michigan (southeast shore)	22,000	170	
2	Lake Michigan (north shore)	9,000	990	
2	Lake Huron (west shore)	5,600	160	
2	Lake Superior (south shore)	4,600	880	
3	Lake Ontario (north shore)	3,000	210	
3	Lake Huron (east shore)	1,000	550	
3	Lake Superior (north shore)		310	
3	Georgian Bay		570	
	1897–1901.			
1	Manistee and Frankfort	58,900	1,690	+ 18
1	Lake Erie (Canadian)	28,900	168	+ 78
1	Lake Michigan (southeast shore)	6,700	96	− 43
2	Lake Michigan (north shore)	7,300	1,200	+ 21
2	Lake Huron (west shore)	6,300	148	− 6
2	Lake Superior (south shore)	9,200	490	− 44
3	Lake Ontario (north shore)	3,500	175	− 16
3	Lake Huron (east shore)	1,200	310	− 43
3	Lake Superior (north shore)	194	164	− 47
3	Georgian Bay	152	166	− 70
	1902–1906.			
1	Manistee and Frankfort		2,344	+ 28
1	Lake Erie (Canadian)	29,523	169	+ .5
1	Lake Michigan (southeast shore)		440	+350
2	Lake Michigan (north shore)	7,300	1,500	+ 25
2	Lake Huron (west shore)	9,100	160	+ 6
2	Lake Superior (south shore)	6,400	500	+ 2
3	Lake Ontario (north shore)	2,600	170	− 2
3	Lake Huron (east shore)	1,300	350	− 1
3	Lake Superior (north shore)		128	− 22
3	Georgian Bay		156	− 6

TABLE 17*a*.—SHOWING THE RELATION BETWEEN THE AVERAGE PLANT OF WHITEFISH FRY PER SQUARE MILE PER PERIOD AND PER POUND CAUGHT PER PERIOD TO THE AVERAGE PERCENTAGE OF INCREASE OR DECREASE IN THE CATCH OF EACH PERIOD OVER THE PRECEDING PERIOD.

	Whitefish areas.	Average plant per square mile per area for five-year periods.	Average plant per pound caught per area for five-year periods.	Average percentage of increase (+) or decrease (−) of period 2 (1897–1901) over period 1 (1892–1896) and of period 3 over period 2.
1	Manistee and Frankfort Lake Erie (Canadian) Lake Michigan (southeast shore)	28,000	96	[a] +72.0
2	Lake Michigan (north shore) Lake Huron (west shore) Lake Superior (south shore) Lake Ontario (north shore)	10,000	32	+ 0.7
3	Lake Huron (east shore) Lake Superior (north Shore) Georgian Bay	2,200	11	−26.0

[a] If we exclude Lake Michigan, southeast shore, on account of the phenomenal increase of 350 per cent in the third period, this value becomes +31, but there appears to be no valid reason for such exclusion.

In table 17*a* is shown the relation of the average intensity of plant of each of the three groups of areas to the average catch in the same areas. The first column contains the average of the plant for the areas of each group for the three periods expressed in fry per square mile and the second column contains a like average expressed in fry per pound of whitefish caught. Thus the value 28,000 in the first column of table 17*a* is obtained by adding all the numbers in the first column of table 17 opposite the areas of the first group and dividing the sum by 9, and the remaining values in columns one and two of table 17*a* are obtained in like manner. The percentages in the third column of table 17*a* are obtained by adding for each group of areas the percentages given in the third column of table 17 and dividing by 6 in the case of groups 1 and 2 and by 8 in the case of group 3.

It thus appears that, on the average, a plant of approximately 30,000 per square mile of whitefish area or of 100 per pound of whitefish caught is correlated, under existing conditions, with an increase of 72 per cent in the catch; a plant of 10,000 and 32 with a practically stationary whitefish product; a plant of 2,200 and 11 with a decrease of 26 per cent in the whitefish product. This appears to the writer to amount to a mathematical demonstration of the efficacy of the planting of whitefish and to afford a measure of the intensity of plant necessary. This measure applies, of course, to present conditions; as the whitefish production increases it is possible that a plant of less than 100 per pound will suffice to maintain the fisheries.

In table 22 is given the total plant and catch for the Great Lakes and from this appears the average intensity of plant for 1903, the last year for which data are available for the catch. The intensity of the plant per pound caught is here

shown to be approximately 50. It appears therefore that the plant should be annually at least twice what it was in 1903. If the writer remembers correctly the cost of producing whitefish fry has been in the recent experience of the United States Bureau of Fisheries about two cents per 1,000 in Michigan. At this rate the cost of planting per pound of fish caught would be about 2 mills.

This correlation of an increased output of whitefish with a large intensive plant of fry and of a reduced production of whitefish or a stationary product with a small or diffuse plant of fry holds good in waters which are fished under the same restrictive legislative enactments. The Canadian waters of Lake Erie fall at one end of the above series, while the Canadian waters of Lake Superior fall at the other end of the series. These waters are fished under the same laws, dominion and provincial. The differences in their output can not therefore be referred to differences in legislative control. The Manistee-Frankfort area and the Michigan southeast-shore area are fished under American nonrestrictive enactments, while the Canadian waters of Lake Erie are fished under the restrictive laws already referred to, and yet both, having received large and intensive plants of whitefish fry, have yielded increased returns in spite of differences in the fishing regulations.

The writer is forced to conclude that the increased production of whitefish in certain areas of the Great Lakes for the averages of five-year periods is due not to legislative enactment, but to the liberal and intensive planting of fry.

EFFECT OF LEGISLATIVE ENACTMENT ON WHITEFISH PRODUCTION.

An analysis of the fisheries regulations of the Dominion of Canada, the Province of Ontario, and the State of Michigan, under which the fisheries were carried on, the data of which are presented in this paper, can not be here undertaken. An act of the Michigan legislature of 1897 provides that, with certain minor exceptions, "it shall be unlawful for any person to fish with any kind of net whatever in the waters of this State from the thirtieth day of October to the fifteenth day of December." The fisheries regulations of the Dominion of Canada provide a close season for whitefish from November 1 to November 30, inclusive, in the Province of Ontario, but certain waters of Lake Erie and the Detroit River and Lake St. Clair are excepted by recent enactment. So far as the close season is concerned the Michigan and Canadian regulations are in essential agreement. They both aim to protect the whitefish during the spawning season. It is quite possible that the improvement in the whitefish fisheries in Michigan waters in recent years, as shown in the tables in this paper, is in part due to the close season which has been in force for about half of the period covered by these tables. That the improvement is not due wholly to the close season is clear when we remember that the Canadian whitefish catch has declined in many regions where a close season is enforced. The close season as

it now is limited is therefore not in itself sufficient to bring about an improvement of the fishery for whitefish.

Under the regulations of the Dominion of Canada fisheries officers are empowered to regulate the distances between nets, and if the writer understands these regulations, the fishing grounds are leased and the fishermen licensed. The result of this system is that a much smaller number of nets, or a much shorter total length of nets, is in use in the Canadian waters of the Great Lakes than in the American waters. In tables 18 and 19 are shown the data for the plant and catch of whitefish for the Canadian and American waters of Lakes Erie and Ontario for the only years for which American statistics are available in which it is possible to discriminate the true whitefish from related forms. From these it appears that the total length of gill and pound nets in use in the American waters of Lake Erie was in 1893 about twenty times that in use in Canadian waters, although the Canadian and American waters have approximately the same area. The Canadian nets in that year took about four times as many pounds of fish per fathom of length as the American nets. In 1899 the American nets are still of about twenty times the length in total of the Canadian nets, which are taking between four and five times the weight of fish per fathom. In 1903 the American nets still exceed the Canadian more than ten times, and the Canadian are taking more than ten times the weight of fish per fathom. In this year the weight of whitefish taken in the waters of the two countries is the same. An examination of tables 11 and 12 shows that in Lakes Superior and Huron the American nets exceed the Canadian in total length and the Canadian nets exceed the American in catch per net fathom. The latter statement is true only if we assume that the whitefish are taken in the waters of both countries in the same proportion to other fish.

TABLE 18.—COMPARISON OF THE ANNUAL CATCHES AND PLANTS OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN UNITED STATES AND CANADIAN WATERS OF LAKE ERIE FOR THE THREE YEARS 1893, 1899, 1903.

Canada, north shore, whitefish area 2,100 square miles.

Year.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1893	256,000	121	5.17	58,000,000	27,619	226	49,500	23
1899	431,000	205	3.99	60,000,000	28,571	139	107,900	51
1903	303,000	144	1.79	62,000,000	29,523	204	169,300	80

United States, south shore, whitefish area 2,000 square miles.

1893	1,292,000	646	1.3	22,570,000	11,285	18	988,900	485
1899	2,066,000	1,033	.88	104,930,000	52,465	50	2,325,200	1,164
1903	303,000	152	.16	90,961,000	45,480	30	1,816,300	908

TABLE 19.—COMPARISON OF THE ANNUAL CATCH AND PLANTS OF WHITEFISH AND TOTAL LENGTH OF NETS IN USE IN UNITED STATES AND CANADIAN WATERS OF LAKE ONTARIO FOR THE YEARS 1899 AND 1903.

Canadian waters, whitefish area 1,400 square miles.

Year.	Catch.			Plant.			Nets.	
	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1899	259,000	185	1.5	5,050,000	3,607	19	168,200	120
1903	97,000	69	.52	3,000,000	2,142	30	186,400	133

United States waters, whitefish area 800 square miles.

1899	161,900	202	2.0	13,475,000	16,847	83	79,700	99
1903	25,400	32	.22	43,920,000	54,900	1,729	114,400	143

It seems clear to the writer that limitation of the length of the nets in use has not resulted in an improvement of the whitefish production. The whitefish catch in Canadian waters of Lake Erie has diminished and again increased (see table 9), although the length of nets has remained but a fraction of that on the American side of the same lake. The same thing has happened on the American side of the lake, if we may judge by the only available statistics, those of the State of Pennsylvania, which are given in table 21.

In table 20 are shown the lengths of nets used in American and Canadian waters of Lake Erie, as compared to the total catch of all fish in the same waters. From this it appears that when all fish are considered the Canadian nets took in 1899 about four times as many pounds of fish per fathom as the American nets, while in 1903 they took about three times as many pounds.

TABLE 20.—COMPARING IN ROUND NUMBERS THE TOTAL LENGTH OF GILL AND POUND NETS AND THE CATCH OF ALL FISH IN CANADIAN AND AMERICAN WATERS OF LAKE ERIE FOR THE YEARS 1899 AND 1903.

Year.	Canadian waters.			American waters.		
	Nets.	Catch.	Catch per net-fathom.	Nets.	Catch.	Catch per net-fathom.
	Fathoms.	*Pounds.*	*Pounds.*	*Fathoms.*	*Pounds.*	*Pounds.*
1899	107,900	10,063,000	93	2,325,200	58,394,000	25
1903	169,300	5,409,000	32	1,816,300	23,189,000	12

TABLE 21.—SHOWING IN POUNDS THE ANNUAL CATCH OF WHITEFISH IN THE PENNSYLVANIA WATERS OF LAKE ERIE FOR THE YEARS 1892–1906, INCLUSIVE; FROM THE RECORDS OF THE PENNSYLVANIA FISHERY COMMISSION.

Year.	Pounds.	Year.	Pounds.
1892	15,000,000	1900 and 1901	57,840,000
1893	19,800,000	1902	44,560,000
1894	25,000,000	1903	19,836,000
1895	42,000,000	1904	39,200,000
1896	30,000,000	1905	34,489,000
1897	43,000,000	1906	36,468,000
1898 and 1899	32,000,000		

TABLE 22.—SHOWING THE ANNUAL CATCH AND PLANT OF WHITEFISH AND TOTAL LENGTH OF NETS USED IN THE GREAT LAKES, EXCLUSIVE OF LAKE ST. CLAIR, FOR THE YEARS 1899 AND 1903.

Lake Michigan, whitefish area 2,600 square miles.

Year.	Total pounds.	Pounds per square mile.	Pounds per net-fathom.	Total fry.	Fry per square mile.	Fry per pound caught.	Total fathoms.	Fathoms per square mile.
1899	1,510,000	503	.58	53,500,000	20,577	35	2,605,600	1,002
1903	1,973,000	682	.77	6,000,000	7,307	3	2,564,400	986

Lake Huron and North Channel, whitefish area 9,300 square miles.

1899	1,457,000	158	1.9	24,000,000	2,580	16	756,500	81
1903	1,525,000	163	2.3	39,000,000	4,193	25	649,600	69

Lake Superior, whitefish area 7,500 square miles.

1899	1,316,000	175	1.7	16,700,000	2,226	12	736,600	98
1903	1,358,000	180	1.9	32,000,000	4,266	24	721,400	96

Lake Erie, whitefish area 4,100 square miles.

1899	2,497,000	609	1.0	196,930,000	48,031	78	2,433,000	593
1903	606,000	147	.30	152,961,000	37,307	252	1,985,000	484

Lake Ontario, whitefish area 2,200 square miles.

1899	422,000	191	1.7	18,725,000	8,511	44	247,800	111
1903	122,000	55	.40	41,000,000	18,636	336	300,800	136

All Great Lakes,[a] whitefish area 25,700 square miles.

1899	7,202,000	280	1.0	309,855,000	12,056	43	6,779,500	263
1903	5,584,000	217	.89	270,961,000	10,543	49	6,221,200	242

[a] Exclusive of Lake St. Clair.

Total length of nets in use seems, therefore, not to have affected the total catch of whitefish. The explanation of this apparent contradiction is probably as follows, although this explanation is offered with much reserve: When fishing is begun in a virgin water, the catch depends necessarily on the amount of apparatus in use. As the rate of catch per unit of apparatus diminishes, which it invariably does, there comes a time when it ceases to be profitable to multiply the amount of apparatus, and as a consequence the number of units of apparatus ceases to grow. The relation of the amount of apparatus to the catch per unit of apparatus is, where no restrictions exist, a self-regulating one. The apparatus is sure to increase to the point where its use barely affords a profit to the user. The total apparatus is not in the water because required in order to catch the total amount of fish actually taken; it is there rather because each fisherman hopes to take the fish which would otherwise fall to another. If, now, the amount of apparatus be diminished, the same number of fish will still be taken in the diminished number of nets until the rate at which they are caught falls below the natural rate of increase of the fish, when, of course, the total catch of fish will increase. If these considerations are well grounded, the regulation of the number or length of nets per unit area does not act to preserve the fisheries unless that regulation proceeds to an extreme that it is not likely to reach in practice. So far as the preservation of the fisheries is concerned, the regulation of the length of nets to be used on unit area may well be left to competition, provided competition is in some way insured. These remarks do not apply, however, to regulation of the length or location of those nets which might impede the movements of fish during the spawning season; they assume, rather, that the spawning season is a close season.

To reduce the length of nets per unit area is, however, advantageous in another way, since it tends to lessen the cost of taking the fish and should make it possible to furnish them to the public at a less price. If fishing grounds are leased in such a way as to insure competition among lessees and to prevent the leases falling into the hands of a single lessee, and if the length of nets permitted on unit area is then restricted, the fish should come to the market at a lower price, for each fisherman would be compelled to take the fish at a less cost to himself and competition would compel him to market them at a less cost. This principle is commonly applied in another way by the licensing of hunters and sport fishermen and the limitation of the catch that they are permitted to take. Here, where pecuniary profit is not an inducement to increase the catch, it is not regulated by the cost of getting it. The sport fisherman tends to get all he can no matter at what cost, and hence it is necessary to regulate the size of his catch by law in order to prevent his exhausting the supply of fish. In commercial fishing exhaustion does not take place, because it is not profitable and it is necessary to regulate the apparatus used only in order to

lessen the cost of fishing. The conclusion reached in this section is that neither the close season nor regulation of the amount of apparatus is in itself sufficient to increase the output of the whitefish fisheries of the Great Lakes. The close season is presumably of assistance and should be preserved, since it protects the fish when they may be most readily taken in large numbers. The regulation of the length of apparatus to be employed in the whitefish fisheries has not resulted in preserving the fisheries, but is presumably advantageous in lessening the cost of operation, since it increases the number of pounds of fish taken per unit of net without reducing the total catch.

SUMMARY OF CONCLUSIONS.

1. The possible modes of increasing the production of whitefish in the Great Lakes are discussed and the conclusion reached that under existing conditions there are but two modes available, planting of whitefish fry and restrictive legislation. The problem is then stated to be a statistical one, that of determining by the study of existing statistical data the effect on the whitefish catch of the lakes of the planting of whitefish fry and of various forms of restrictive legislation. It is shown that it is necessary to have statistics for a continuous period of years for true whitefish only both for plant and catch and under various legislative restrictions. The necessity of discussing average catches with reference to unit areas of fishing ground is insisted on. Finally, it is shown that the necessary statistics are to be found only in the records of the Michigan Fish Commission and in those of the Department of Marine and Fisheries of the Dominion of Canada.

2. The habits of the whitefish are discussed, with the conclusion that the fish is a bottom feeder, restricted in its range during nine months of the year to waters of very definite depth. The depths assigned by investigators to the whitefish are then tabulated for each of the Great Lakes, the areas showing these depths are charted, and the extent of these areas measured in square miles. The whitefish areas as thus defined are then briefly described for each lake and it is shown that they are not in all cases continuous areas. Evidence is then adduced to show that the whitefish are local in their habits, so that each part of each area supports its own group of fish, which are in large measure confined to the area, leaving it only in fall when going inshore to spawn and in spring or summer for about two months.

3. In studying the relation of the plant of whitefish fry to the catch it is found that in those lakes or parts of lakes where there has been a large and intensive plant of whitefish fry (30,000 per square mile) there has been a correlated increase in the catch of whitefish (72 per cent); in those lakes or parts of lakes in which there has been a moderate plant of whitefish fry (10,000 per square mile) there has been a slight increase in the catch of whitefish or the

catch has remained nearly constant; in those lakes or parts of lakes in which there has been a small plant of whitefish fry (2,000 per square mile) or no plant, there has been a reduction in the catch of whitefish (26 per cent). (Certain exceptions to this statement are also noted.) It is shown that under Canadian restrictive legislation the whitefish have diminished in waters where planting of fry has been at a minimum and have increased in waters where planting has been liberal; that whitefish have increased in American waters where there has been no restrictive legislation (or little) and have diminished in Canadian waters of the same lake under restrictive legislation. These increases and decreases are stated to be, therefore, in relation to the plant of whitefish fry and not to legislative control.

4. Discussion of the effect of legislation on whitefish production leads to the conclusion that (*a*) a close season during the breeding period is probably advantageous to the production of whitefish, although the data at hand do not furnish any evidence on that score, and (*b*) that a practicable regulation of the number of nets or the length of nets to be used in unit area of the lake does not increase the production of whitefish, but does tend to greater economy in the fishing, since the same number of pounds of fish are taken with fewer nets.

MEASURES RECOMMENDED AS MEANS OF INCREASING WHITEFISH PRODUCTION IN THE GREAT LAKES.

1. It is recommended, as a result of the foregoing study, that the output of whitefish fry be increased as rapidly as possible, as affording the most certain means of increasing the whitefish production.

2. That an intensive plant of at least 100 fry per pound of whitefish caught be made on depleted areas. (Lake Ontario and the southern waters of Lake Michigan are in need of especial attention.)

3. That a close season be observed during the breeding season of the whitefish as at present, but only for such waters as are not under federal control (see sec. 4, below).

4. That commercial fishing with pound nets and seines be permitted in the waters of the Great Lakes during the breeding season of the whitefish wherever the state or national authorities are prepared to undertake to care for the spawn of the fish taken; the fishermen to be under legal obligation to permit the use of the fish taken by them for the purpose of spawntaking.

5. It is suggested that central control of the fishing operations of the Great Lakes is highly desirable. Whether this is possible in American waters through federal control or through concerted action of the states is a question that can not be discussed here. A central control, under which fishing grounds should be leased and fishermen licensed, would, if properly administered, reduce the cost of fishing and make possible more extended

artificial propagation. The central authorities should have power to modify the fishing regulations pending legislative action. Such a system might be made self-supporting.

6. The need of more exact knowledge of the habits of the whitefish and of all the conditions under which it lives is very evident. In the interest of the fisheries these matters should be subjects of investigations to be carried on under federal auspices, with suitable equipment and for a long period of years.

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DISCUSSION.

Prof. EDWARD E. PRINCE. I do not wish to usurp the time of the congress unduly, but I will say a word or two about the opinions expressed in the two or three papers this morning on the question of whitefish production in the Great Lakes. It is a matter which is of very, very great importance to us in Canada—in fact, I may say I am chairman of a commission appointed by the Dominion government which has the protection of the whitefish, especially of Lakes Huron and Erie, before it. I give the writers of the papers this morning credit for wishing to do something practical in the matter of preserving the whitefish. I give them credit for that. At the same time I, as Canadian commissioner of fisheries and having a good deal to do with administration of fishery laws, see difficulties in the suggestions which were made in the papers this morning, and especially I see this difficulty, that the prohibition of the capture of small whitefish, so long as pound nets or fish traps are allowed, is almost an impossibility—that is to say, the prevention of their destruction. You may try as you will to prevent the taking of small whitefish, but they will be taken. You may prohibit their sale, but they will be handled and in some way disposed of. Therefore the question comes to this: If you adopt a policy which will be extremely difficult or impossible to carry out, it is better to pause before adopting that policy. If you adopt a closed season—and we in Canada, have always favored closed seasons, and have to some extent carried them out (I say that, in justice to our official staff with which I am connected, we have tried to carry out the closed season in Canada)—if you adopt a closed season, which prevents any nets whatever being used and removes all nets from the water, that is an effective measure. You can do that. You can protect the fish by preventing the capture altogether—that is, by taking the nets out of the water for, say, the month of November.

I know that Mr. Clark and others will claim that hatcheries will make up for everything in the way of destruction of fish by nets if you also preserve the immature fish; and one of the strong points in favor of artificial hatching of fish (instead of allowing parent fish during a closed season to spawn) is that great loss arises from nonfertilization of eggs. I think that is a point which is open to discussion, and I will give you an illustration, and then I shall sit down. Sometime ago I was engaged in hatching sea fish, and I hatched about 70 different species; and I tried on more than one occasion to keep some eggs in the laboratory tanks free from fertilization. The sperms which the male shed in the open sea would reach those eggs through the supply pipes wherever they were placed. In other words, it was almost impossible to keep them unfertilized after they were taken from the ripe female. I investigated the same thing in sockeye salmon in British Columbia. I tried on the spawning beds to get eggs which were not fertilized. I went into the water knee-deep to get them and groped about on the spawning beds there, where the fish were engaged in spawning; and I tell you, gentlemen, I have gathered quantities of natural fish spawn on the beds, and I failed, in some thousands of eggs, to get one single egg that was not fertilized, which showed how scrupulously nature accomplishes the fertilization of eggs under natural conditions. At the same time, I do not deny that eggs may escape impregnation, yet, so far as my observations go, the eggs which were deposited by the parent fish are almost to an egg fertilized.

I do not wish to say more, Mr. President, but merely these few words.

The PRESIDENT. The next gentleman.

Mr. C. H. WILSON. I desire, as the representative of the State of New York, to congratulate the gentlemen who have furnished these most interesting papers upon this question. I wish to back it up by the protective element and the department of fisheries of the State of New York. While we give you great credit for what you have done, for what you, in your enthusiasm, hope to do, yet we do not believe the time is ripe when we should sever a partnership with nature and the Almighty. [Laughter.]

The first paper speaks of the effect of pollution of the waters of the Great Lakes upon the spawning beds of the whitefish. If the beds of the whitefish are destroyed by the thousands of acres, as stated in this paper, I submit to you, Mr. President and gentlemen of this congress, that the time has not arrived when we shall fail to take advantage of everything to conserve the food fishes of North America.

An argument is made in this paper regarding the closed season. The writer wishes to close the season for two months, that the commercial fishermen under the guise of gathering spawn for the hatcheries may rush in and slaughter by the thousands the whitefish of the Great Lakes. May I ask you, gentlemen, what risk do you run in having a closed season during the spawning period of the whitefish? By an open season you do invite the continuance of an illicit business already begun in the taking of whitefish eggs for caviare, one seizure of one and one-half barrels of eggs in transit having been made last year. You establish a precedent that will later plague you regarding other varieties of fish.

The enthusiasm of the writer of one of these papers sees the Great Lakes overcrowded with fish; the sober judgment of another says, "We may never expect to return to former conditions;" while the third, uncertain of his position, says, "A closed season may be advantageous." The showing of the enthusiastic and faithful operators of hatcheries is fine and gratifying to all; but the catch, after all, determines the real pounds pressure of their enthusiasm. Successful planting must follow successful hatching, and protection wait upon both; and the argument of all arguments in these papers is the statement that the propagation and protection show increase in the last few years. What protection? Practically all states and provinces bordering on the Great Lakes, save the state of Pennsylvania, with its 45 miles of shore line, have in recent years given protection by a closed season during the spawning time of this valuable fish.

The statement is made that a closed season will interfere with the taking of spawn. Mr. Chester K. Green, who operates a hatchery at Cape Vincent, N. Y., will tell you that the state of New York, which I represent on this floor, has given to the United States Government permission to take all the spawn it wishes for hatchery purposes.

Hon. PAUL NORTH. Representing the state fish and game commission of Ohio, I would state that the question of preserving the whitefish on Lake Erie is a very difficult one, owing to the fact that Lake Erie has four states and the Dominion of Canada bordering, and each and every state has a different law, to a great extent, governing the taking and catching of these fish. It is a notorious fact that up until the last year New York State permitted the fishing with gill nets of 2½-inch mesh, and tons of immature fish were caught at Dunkirk and those points—immature whitefish that were of absolutely no use whatever—in the summer when they are soft and no good. Of course there comes the question that if you stop the catching of fish there you will stop the commercial fishermen of New York from making a certain living. And if we, as a general government of Canada and the United States, regulate this and have a closed season until such a time as the fish come up the lake, why, then, the Ohio fishermen get all the benefit; and you can see where the trouble is going to come in and what a difficult matter it is to handle. But the main thing, in my mind, is that Mr. Clark and Mr. Downing are both absolutely right in their premises that one hatchery will produce more whitefish than all the whitefish in a natural state produce.

You must remember that as the whitefish have decreased the means of taking them have increased. The mileage of the gill nets has increased, and the pound nets have increased, until now in places you will see 30 in one string reaching out into the lake, and it is a wonder that any fish have been left. We should have regulation all along the line—the size, number of pounds they can have in one string of nets; and there must be a regulation, gentlemen, that every whitefish that is taken with spawn must, as far as possible, be put in the hatchery; and if we can have 50 hatcheries on Lake Erie there is no question but what we can have a very large increase in the quantity of that fish, as shown by the effect of the 2 hatcheries on the lakes, which have in the last five or six years increased the catch until last year we had the biggest catch on Lake Erie we have had in the last fifteen years; all due to those 2 hatcheries. Nature has been doing as much as she could; but those 2 hatcheries have done the work. Mr. Downing and Mr. Clark know what they are talking about; they know what the conditions are; they know that the hatcheries will do the work; and that if you can by this means conserve every whitefish until you get its spawn and then run that spawn through a hatchery you will have all the whitefish in Lake Erie and more than it ever had before. [Applause.]

Mr. KELLY EVANS. I should just like to take up my three minutes by calling attention to a point in one of the papers that was read this morning, in which the statement was made that while we had a closed season on the Canadian side of the Great Lakes the fish in our waters were not as plentiful as they were in the waters on your side of the lakes, at several points. I would remind one or two of the fishery commissioners present that they have already spoken to me at different periods of time in reference to using nets by arranging with the Canadian authorities to allow them to gather eggs on the Canadian side of the lakes. Does it not seem curious to you that if the fish are to be found in very much larger quantities on their side they should wish to come to our side for eggs? That is one point I wish to make.

The second point I wish to make is this, that if the condition outlined in the splendid papers read this morning is practically possible to bring about, you will have reached undoubtedly a Utopian condition; but on our side of the water, at any rate, I feel convinced that that Utopian condition of things will require a great many years to reach. In consequence, if this congress came out very strongly as supporting the general proposition that hatcheries could be depended upon entirely, and that nature might be ignored, it might result disastrously on our side of the water. If at any point in our international waters all the spawn-bearing fish can be so taken care of that their spawn is in no way lost, possibly the proposition of depending upon the hatcheries alone is the best one; but until that condition of things has been brought about it is a very dangerous thing to say to great nature, "We need your assistance no longer." I therefore, from these points of view, urge the congress to go very slowly on this question of abandoning great Dame Nature. [Applause.]

Dr. BARTON W. EVERMANN. Mr. President, I would like to discuss this question, but I think I shall refrain. I would like to ask one question, however, which I think can be answered by Superintendent Lambson, of the California station. If I have been correctly informed, the natural spawning beds of the Sacramento salmon in the Sacramento River basin have been practically wiped out of existence through mining and other operations of that kind, so that even if no salmon were caught in the Sacramento River either for commercial or for hatchery purposes and all salmon in that stream were allowed to ascend to such spawning beds as they might find they would probably amount to nothing; they would be unable to find any suitable spawning beds, because those beds have been destroyed. But through artificial propagation in the Sacramento basin I understand that the catch of salmon in that river now is very large. Some years it is larger than it was ever known to be before artificial propagation began and before

that river was so much changed physically because of the results of mining and agricultural operations. If those are the facts, it seems to me that they point a very important question and suggest very strongly the wisdom of the course which has been recommended by two or three gentlemen in the papers they have presented. It appears to me that we should no more depend upon natural reproduction in any of the species of fish that we can handle than we should depend upon natural reproduction of corn or potatoes or any other thing that may be left to the wild. [Applause.]

Dr. TARLETON H. BEAN (New York). Just a word, Mr. President and gentlemen of the congress, merely to remind you of the present condition of the shad fisheries of the United States, which, it appears to me, is one of the very best illustrations of what can be done by artificial culture as against natural reproduction in streams that have been more or less polluted. I shall go not very far south of the Hudson River and the Delaware for my illustration, and say the Potomac. You gentlemen know as well as I that to-day the fisheries—the commercial fisheries of those rivers, especially the shad fisheries—rest absolutely on an artificial basis; and they have so rested for the past quarter of a century. It is within my knowledge and within your knowledge that in 1874 shad were selling in the Washington markets at 75 cents apiece on the average. You know what they are worth to-day, and you know why it is that you can buy them to-day for one-third the price that you paid in 1874. I will not enlarge upon this topic, but merely remind you that the Hudson, the Delaware, and the Potomac for the past quarter of a century have been increasingly polluted. The natural spawning beds or grounds have been covered with cinders and other waste products of industries; and without artificial propagation there would be no such thing as a run of shad in the North River or the Hudson River to-day, as there has been in 1907 and 1908, equaling the catch of more than twenty years ago.

Mr. FRYER. I do not gather that all the spawning grounds of all the whitefish in the Great Lakes are polluted; neither do I gather that they are spoiled by refuse from timber works, sawmills, or from any other such cause.

Mr. FRANK N. CLARK. If I understand you correctly, you do not understand that the spawning grounds of the whitefish are polluted. They most certainly are. In my paper I speak of the Thunder Bay River region, where the beds are polluted out 9 miles in a bay that is 30 miles across, and there are no whitefish in that territory where they used to spawn in great numbers.

Mr. FRYER. If that applies equally to all the spawning grounds of the whitefish in the Great Lakes, then, of course, my point falls.

Mr. CLARK. It does not apply to all.

Mr. FRYER. Then the point I wished to make is that, assuming there are natural spawning beds still left in the Great Lakes——

Mr. CLARK [interrupting]. Oh, yes.

Mr. FRYER [continuing]. I am glad the assumption is correct for the sake of the fisheries themselves. My argument is this: There is a great distinction to be drawn between the case of the Great Lake fisheries and the cases that have been referred to, such as the shad fisheries of the Hudson and elsewhere, where it is found that all the spawning beds are either polluted or are so cut off from the fish as to be practically unavailable, and I expect that in the paper that is about to follow, on the fisheries of the Rhine, you will find information given which will enforce the point that there is a great distinction to be drawn between those cases where nature still has a little room left to perform its own functions and the cases where the natural conditions have been practically destroyed; and, on the premise that there are still natural spawning beds available for the whitefish, I would venture to support the view put forward by Professor Prince, that you have great cause for hesitation before you put aside the question of improving or endeavoring to improve these fisheries by restrictive measures and rely

solely upon the measures proposed in those three very excellent and admirable papers which were read this morning, the sincerity of whose authors one can not fail to appreciate and admire, however one may differ from their conclusions.

Professor Prince referred to the difficulty of regulating the sale of undersized fish. In England it has been found—as has been recorded in very quaint language in some old statutes—that although the law prohibited the sale of small fish their capture was inevitable; and when such methods of capture as hooks and lines were employed, and the small fish had to be thrown back into the sea, they were destroyed, and the public were thus deprived of a certain supply of fish. This is another illustration of the difficulty referred to by Professor Prince.

At the present moment we have in Europe a difficulty in connection with certain grounds on the southeastern part of the North Sea, where very large quantities of what are known as immature or undersized plaice are caught, with very few adults. The suggestion was therefore made in that case that an international regulation might be passed which would prevent the sale of fish under a certain size, the idea being that although the prevention of sale would not in itself prevent the capture, yet the proportion of small fish taken on those grounds is so large that if the sale were prohibited it would not be worth the while of the fishermen to fish there any longer, and so, indirectly, under those circumstances, the prohibition of sale would have the same effect as the prohibition of capture. A period of one hundred and eighty seconds is not very long to deal with such an important question as this, but I would like to enforce one point made in the last paper, namely, that our knowledge with regard to the spawning of fish is not as perfect as it ought to be. On the mere point of fertilization of the ova, a very simple test would settle the question as to the proportion of the ova fertilized naturally. I may, incidentally, indorse Professor Prince's experience in the matter of salmon eggs. I have myself collected salmon and trout ova fertilized naturally, under normal conditions, and I have not found 5 per cent of the eggs unfertilized, so that, prima facie, there seems very great reason to doubt that the proportion of unfertilized eggs in the case of the whitefish can possibly be 99 per cent, as suggested.

If I might intrude one minute longer, I would throw out the suggestion—I do it with great diffidence, because I do not know all the local details, but as a very broad proposition for consideration—that it might be possible to arrange between the United States of America and the Dominion of Canada for the waters of the Great Lakes to be treated as a common fishery, common to the two countries, subject to common laws, equally enforced on both sides, and based on the most perfect knowledge that it is possible to obtain with regard to the habits of fish, and of course with regard to the habits of man, as to which I personally, as I said before, have insufficient knowledge. I just make the suggestion for consideration, with the addendum that if such an idea were accepted it might be possible to arrange that the fishermen who are interested in conducting these fisheries should themselves contribute to the expense of the administration and regulation of the fisheries in these waters. Whether that administration were limited to regulations only or whether it included artificial culture does not matter. This might be done by means of a system of tolls leviable not merely by licenses to the fishermen, giving them the right to fish, but on the quantity of fish which they brought ashore, no matter where they landed it, so long as it was taken in the Great Lakes.

I make the suggestion with very great diffidence, but if it were possible to elaborate it I could give you several reasons in support of it.

Mr. J. W. Titcomb. I will answer the question raised by Professor Evermann about the run of salmon in the Sacramento River. Practically all of the salmon which ascend the river by the canneries are caught at the Bureau's hatchery and stripped of their eggs. Occasionally, say once in three or four years, with a very high freshet, the fish get by, or a part of them get by. The fish in the Sacramento River have

increased steadily for the past ten or fifteen years. The proportion of eggs which the Bureau is able to collect to-day, as compared with that of ten or fifteen years ago, is several hundred per cent greater. The observations of Captain Lambson as to the natural fertilization of the salmon show that about 75 per cent are fertilized under natural conditions; but further observations show that of the 75 per cent which are naturally fertilized fully 95 per cent are smothered in the sand, so that eventually only a few hatch. Under artificial conditions we fertilize from 90 to 95 per cent; we hatch and develop as fry from 90 to 95 per cent of eggs fertilized. The fishery there is dependent entirely on artificial propagation, and during the last ten or fifteen years has steadily increased.

In the shad fishery, which Doctor Bean has alluded to, take, for instance, the Potomac River: After the Fish Commission began its work of artificial propagation the commercial fishery came up steadily until the figures for a great many years were perfectly wonderful. We can not show that tremendous fishery to-day, for the reason that the fish are not allowed to ascend the river where we can get their eggs. All our work in the propagation of shad must be done during the spawning season, and the collection of eggs is dependent on the run of shad during that season. They can not be caught at other seasons of the year because they are not there.

I think that both the salmon and shad are an illustration of the whitefish question, to show that the open season is desirable, if we can have along with it all the necessary hatcheries and spawntakers to conserve the eggs which would otherwise go to waste. [Applause.]

Mr. W. E. Meehan. Mr. President and gentlemen, I did not intend to take part in this discussion, for the reason that it occurred to me that the papers read this morning cover the question so completely and are so fully in accord with the experiences I have had in the fisheries of Lake Erie and the Delaware River in the case of shad, whitefish, herring, and other fishes that are caught in the commercial nets for market purposes. It seems to me that the maintenance of fish by artificial propagation is necessary—that the latter is necessary to maintain fisheries. The plea that, although we may believe a closed season for non-nest-building fishes is not needed because fish hatcheries can better keep up the supply of fish than natural propagation, we ought not publicly to say so for fear some harm will be done to some other country which does not propagate is, to my mind, much like the warning which the man gave another not to teach his children to read for fear they would later on come to read pernicious literature.

All experiments made have shown that artificial propagation is necessary for the maintenance of fish in the water; that with increased population and increased demand it is impossible to maintain a supply by natural propagation. Artificial propagation has increased the supply of whitefish in Lake Erie and probably in the other lakes; it has increased the herring; it has increased the shad in the rivers. Without artificial means we would have no shad to-day. Artificial propagation has made the whitefish industry once more profitable. The best policy, in my estimation, is that which is outlined by Messrs. Downing, Clark, and Reighard, to give the freest possible fishing for whitefish, herring, and the like during the summer months when the water is warm, when the fish are soft, and when the runs of fish are apt to be small and immature as to size. Catch the large fish and give the small fish a chance to grow. If closed seasons were made during the spawning period, there is scarcely a fish-cultural station on the Great Lakes that would be filled, unless the government and the states had about every boat employed in fishing. In the state of Pennsylvania, for the hatcheries set apart particularly for the propagation of the lake fishes, it will require every boat going out of the port of Erie to fill those hatcheries, and it is doubtful even then if the houses would be full. The more fish that are hatched, the greater must be the percentage of increase in suitable waters.

These are my reasons for supporting and believing the papers of this morning as enunciating the true doctrine of increasing the food-fish supply. [Applause.]

Mr. SEYMOUR BOWER (Michigan). Mr. President and gentlemen, I had not intended to take any part in this discussion. I will say, however, that for many years I have been in hearty accord with the views regarding whitefish propagation as expressed in the papers just read. In fact, I think Mr. Clark, Mr. Stranahan, and others here will bear me out in saying that I was one of the pioneers in advancing those views. To me this proposition seems so simple as to be hardly worth a moment's consideration if we are right as to the value of what is known as artificial propagation. As evidence of its value I can state that the catch of whitefish in Michigan waters of the Great Lakes is steadily increasing, has been for a number of years, and is now very nearly double what it was ten years ago. To be more exact, in the latter part of the nineties the annual catch was a little over 3,000,000 pounds on an average, while in 1906, the last year for which we have complete statistics, the catch was over 5,000,000 pounds. The figures for 1907 and 1908 are not compiled, but our agent who is now in the field is of the opinion that both years will show a still further increase.

There is just one thought in connection with this matter which I desire to present. There are two great divisions in the forces of nature, which we might term destructive and constructive. The existence and development of all forms of life are possible only through the destruction of some other form, either animal or vegetable. Now, as fish spawn in nature, the ova are subject not only to the constructive forces of their environment, but also to many destructive ones; but when transferred from that environment to an artificial or protected one, they are separated from these destructive forces and are then subject only to those that are constructive, with the result that production is increased many fold. If that proposition is true, and we have most convincing evidence that it is, the situation is greatly simplified. We should apply this principle wherever practicable; should take advantage of every opportunity to prevent the ova of the better class of food fishes from being thrown into contact with the destructive forces of nature. This is the vital point or principle in fish culture.

The PRESIDENT. Professor Birge, have you something to say in this matter? We would like to know your views.

Prof. E. A. BIRGE. I have no right to speak with any authority on this subject. I have been in agreement with the views expressed in the papers which were read this morning, but I have no such personal knowledge of whitefish culture or the whitefish industry as those gentlemen who have spoken on the subject.

Mr. W. T. THOMPSON (Colorado). I would like to say a few words along the line of thought advanced by Professor Evermann. I believe I can bring evidence from Colorado which will place the result attained by hatchery methods beyond question. Mr. Titcomb stated in his lecture this morning that larger collections of eggs from wild brook trout could be made in Colorado than in any other section. I wish to call your attention to the fact that this species is not indigenous to our state, but was first introduced about twenty-five years ago. No trout were found in the state at that time except the native species, chief among which was the blackspotted trout (*Salmo clarkii*).

The brook trout was first introduced, in small numbers, about 1882 or 1883. Some two years later the introduction of the rainbow trout was commenced in a very limited way. Coloradoans had been accustomed to the native trout for years; the waters were thickly populated with them when the white man first arrived. Naturally, they thought they would always have them without effort on their part, consequently there was no demand on the hatcheries for them; hence, we produced none. The adult fish were allowed to deposit their spawn naturally, "according to the dictates of their conscience," as we might say. I might add that the spawning beds were not polluted to any extent and were and are still accessible.

Now, let us see what has been the result in Colorado after a period of twenty-five years: Our hatcheries, beginning with these first small plants made from eggs secured from other points, gradually began to secure both brook and rainbow spawn in increasing numbers from our own waters. The Gunnison River is one of our typical trout streams. Twenty-five years ago it was full of the native trout. None were taken from it for spawning purposes, consequently it can not be claimed that the hatcheries interfered in any way with their natural reproduction. The hatcheries, meanwhile, have been industriously collecting both brook and rainbow eggs, planting the resulting fry in public waters in increasing numbers, year by year. To-day, after twenty-five years of this policy of noninterference with the natives, this species has become practically extinct in the Gunnison River, and the condition in this river is typical of what has transpired in our other streams. This same Gunnison River is still celebrated for its trout, but the reputation rests entirely on the introduced species, the hatchery products, the rainbow of the Pacific slope and the brook trout of the east, which in our Colorado waters found a congenial home and attained a higher degree of excellence than in their native habitat. Sixty-five per cent, possibly more, of the trout in the Gunnison to-day are rainbows, the balance are brooks, with an occasional native, but the latter are very rare.

So far as Colorado is concerned, both of these varieties are entirely the product of the hatcheries. Nature, or, more properly speaking, the natural method of spawning, had practically nothing to do with this remarkable increase. That this is a fact is amply attested by the rapid decrease among the natives when left to propagate naturally. Through the work of the hatcheries, our streams are still well stocked, but with the brook and rainbow trout.

Mr. Titcomb spoke of a lake containing an island, around which the fish circulated in great numbers during the spawning period. If we allowed these fish to spawn according to nature, there is no doubt but that lake would continue to be thickly populated, but it would not benefit other waters. Operated under fish-cultural methods, assisting nature in her efforts, we have taken over 6,000,000 eggs from this island lake. We could have taken more had we proper facilities at the time. With the fry from these eggs, we were enabled to stock many of the lakes and streams of the state. I believe no better illustrations can be given of the value of fish-cultural methods than we can bring you from Colorado.

Mr. FRANK N. CLARK. Mr. President and gentlemen, I have very little information to add in the short time allotted to me in this discussion, but I shall try to answer the two or three points which are all I am willing to concede have been made on the other side of this question.

One question, I think possibly from Mr. Fryer, or some other member, in reference to the small fish—speaking of certain nets or grounds where it was almost impossible to get along without catching small fish. Remember what I said: "Prevent any sort of fishing in certain localities where large numbers of immature fish congregate upon the feeding grounds, this legislation to pertain to all portions of the Great Lakes system where the presence of such fish has been established and to be enforced during such month or months as they make their appearance in large numbers for feeding purposes." We do not propose to permit any fishing there at all; wherever the small fish are caught in large numbers should be a government reservation—that is my idea. That is all I have to say about the small fish.

Another gentleman, I think Professor Prince, spoke of the high percentage of impregnation of the fish eggs in a natural way. With the salmon there is no doubt of it; but with trout, i. e., lake trout, not the stream trout, and with the whitefish, I thought it was conceded by all who are interested in fish culture that the percentage of impregnation of the naturally spawned fish was very low. I have always supposed it was conceded. If I might be permitted to state, Mr. President, I think it is of record in some

of our early United States Fish Commission reports, where I personally made certain observations upon this phase of our subject, and I have always supposed that this was why we approved the dry method of impregnation instead of the wet method. Experiments made by me many years ago in taking eggs of the whitefish brought me to these conclusions: You take your eggs in a pan of water with the milt, and you get a fair impregnation; you take your eggs in a pail of water, say 10 gallons, and you get a medium impregnation—perhaps 20, 30, or possibly 40 per cent. If you take your eggs in a barrel of water you may get 15 or 20 per cent. Therefore I have always concluded that where the female whitefish spawned indiscriminately in the water, with the milt no doubt added in the same way, only partial fertilization would result. In fact I believe, Mr. President, that many female whitefish spawn when there is not a male fish anywhere in the vicinity. From that we must, it seems to me, draw the conclusion that where the whitefish spawn naturally it is not possible to have any high percentage of impregnation. Personally, I do not like the word "artificial." There is nothing under the sun artificial about the care or hatching of fish eggs, excepting that you give them care. It is "protected propagation," Mr. President, and I like to use that term. There is nothing artificial in taking the eggs. You merely bring the eggs and the milt together. That is all there is of it; and then you care for them, and the care and attention which is given them in our hatcheries is what I prefer to call protected propagation.

Some speaker mentioned pound nets. Here is the ground that I take. As you will see, I make the penalty very severe to the fishermen; it is the most severe punishment that was ever thought of, in my judgment. Think of it! The third violation stops his fishing. I do not care if he is but 20 years old, he stops fishing the balance of his life. Suppose some of our immensely wealthy fishermen on the Great Lakes—take the A. Booth Packing Company—violate this law the third time, what happens? They must stop fishing or the revenue boat will attend to them.

All this is contained in this paper, and my idea is based on the idea of federal control, not state regulation. I mean federal control by the Dominion of Canada and the United States; not state control or provincial control. Our warden boats go there, and they may find a man violating the law. He is arrested; his license is taken away from him for six months; for the second offense for a longer period.

Might I be permitted to state what I said to a fisherman on the lake? I gave him my idea of this federal control, and what I proposed. I said: "You do not obey these state laws very well?" "Oh, no;" he replied, "we take our chances on getting caught." "You caught a considerable number of fish here one fall out of season?" He replied: "Yes; oh, yes." "Well," I said, "John, I know how many you caught—about $10,000 worth." He answered: "Yes; and I was taken over here and fined $500, but I had $9,500 left." I said to him: "John, what will you do if you are licensed and you violate that law, and have to stop fishing six months?" "Why," he said, "it would almost ruin me for six months." I said: "What will you do if you have to stop for a year?" He replied: "I could not stand it." That is my idea. I do not know whether I have answered all questions or not.

Mr. J. J. STRANAHAN (Georgia). Mr. Clark, you have a better memory than mine, I know. You remember what we published with reference to the fertilization of whitefish eggs on the Detroit River?

Mr. CLARK. Oh, yes.

Mr. STRANAHAN. What was the percentage?

Mr. CLARK. It was very low. I do not know that I can give the exact figures. It might have been one-half of 1 per cent.

Mr. STRANAHAN. Less than 1 in 1,000.

Mr. CLARK. Very low, indeed.

Mr. STRANAHAN. I want to speak only a word. Under the direction of the United States Commissioner of Fisheries, I was instructed to make dredgings on the reefs with

our steamer, using the hose. We did so for several days the latter part of November and the early part of December. We had an inch hose and a rotary pump; and we took up only a few thousand eggs. I can not give you the percentage, but it was somewhere in the vicinity of one egg out of three or four hundred, and, as I remember it now, we got only eleven or twelve impregnated eggs during our two or three days' work. Our work was off North Bass Island, and around the island near the hatchery where I was then superintendent.

Professor PRINCE. There is just one error that I think Mr. Clark would willingly consent to having removed, and that is that spawning grounds in the Great Lakes are all polluted. On the Canadian side there are splendid spawning beds which are unpolluted. There are great spawning grounds in Lake Erie and Georgian Bay unpolluted, and the benefit of these spawning grounds must be felt on the Great Lakes, as the benefit of the hatcheries is also felt. I wish to say that I am as strong an advocate as anybody for artificial culture, and have said so in numerous official reports; but I also think that if you can combine that work with a closed season, then you have an ideal state of things.

Mr. SAMUEL F. FULLERTON (Minnesota). Mr. President and gentlemen of the congress, have you taken into consideration that men whom I claim to be the foremost in the United States to day in their profession have written papers, all in different directions and all coming to the same conclusion? If any of your family were sick and there were a horse doctor and a physician of high standing in the same community, which would you employ—the horse doctor? No, you would take the physician of high standing. Here is Mr. Clark, who has been in the business for forty years, and Mr. Downing has perhaps been in it as long—men whose word is law in regard to fish culture; and we should take their word, not that of the horse doctor. Now, in our state last year we had a law suit; and I think this will illustrate the point I want to make as well as anything else. At that law suit we had the evidence of eleven fish culturists—the foremost men we could get. We went all over the United States for them; and the conclusion they all reached was the same: That not one whitefish or pike perch egg in 500 ever came to maturity. They were sworn men; they had made tests. I have been at it eighteen years, and I have taken eggs off the bottom rocks and off the sand and brought them to our hatchery and hatched them; but I never got 1 per cent of fry. [Applause].

Mr. DWIGHT LYDELL (Michigan). I have been listening very attentively to the speakers, and did not intend to say anything; but when some of them stated that we could get along without Dame Nature, I desire to say that I think we can not. I think all fish culturists are willing to admit that Dame Nature is what we need up to a certain point, when they step in and beat Dame Nature where the whitefish are concerned for the next five months.

I took some dredgings on the Detroit River, under the instructions of the Michigan Fish Commission, several years ago, when they were engaged in the propagation of the whitefish; and out of two quarts that I gathered nearly every day with a dredge, I failed to find any impregnated whitefish eggs. This work was carried on during the months of March and April. No whitefish eggs were collected whatever that were good, although we got quarts and pails of poor ones. That was on the natural spawning grounds.

I do not think that we ought to compare our brook trout or any of our other species of fish, except the lake herring and wall-eyed pike, with our whitefish. The whitefish spawns promiscuously in the water wherever it happens to be. The brook trout clean off their beds in the streams and spawn on them; both the male and the female are there. Take the whitefish run on the Detroit River. The female whitefish come up there in great numbers after the male run has nearly passed by. The first run comprises nearly all males; in the second run you will get ten females where you will get one male. As they are all ready to spawn, I think it would be impossible for one male to attend to so many females; but if the males that are caught from the first run are

held in crates by the fish culturist, and used when the females come on, nearly every egg is saved to be turned loose later as a lively young fish. Our tally sheets which are on file in the Fish Commissioner's office show these statements to be true. So I do not think we ought to compare the brook trout with the whitefish in this discussion at all.

Mr. FRYER. I would like to ask one question, which is, What was the condition of the whitefish fisheries of the Great Lakes say sixty years ago, before there were many of the mischiefs that exist now, such as pollutions and pound nets and other wickednesses on the part of man, and when also there was no such thing as protected reproduction?

One other question on the point of the illustration given us from Colorado. I am in doubt whether the speaker from that State wishes us to infer that the native trout had died out because there was no protected reproduction in its case, or whether we are to assume that it had succumbed to the superior numbers and greater voracity of the alien fish imported into its water.

Mr. PAUL NORTH (Ohio). I do not go back sixty years, but Mr. Fryer would know the difference in conditions on Lake Erie now as compared with sixty years ago if he could realize that we have in Lake Erie on the American side a fleet of nearly 300 tugs with 6 to 8 miles of gill nets to the tug. He could appreciate that, if the same conditions which existed sixty years ago with regard to replenishing the lake were present to-day, we would not have a fish of that kind in Lake Erie.

The PRESIDENT. Now, in regard to the question about the native trout. Mr. Thompson will reply to that question.

Mr. THOMPSON. I intended my hearers to infer that it was owing to lack of artificial propagation that the native trout had died out to so great an extent. I will state that we have in recent years commenced an extensive work with the natives, with the intention of again making them a factor in our streams. The lake Mr. Titcomb mentioned this morning, where the fish circulate around the island in countless thousands, is one of our native trout-spawning fields. It is about 200 acres in extent and has yielded over 6,000,000 eggs in a single season, this quantity being limited merely by our existing facilities.

[The discussion of the whitefish question terminated at this point but was briefly taken up again on the following day.]

The PRESIDENT. Mr. Fullerton has just spoken to me about a matter of general misunderstanding in regard to the whitefish question, and it seems to me to be of sufficient importance to be brought again before the attention of the congress. I will ask him kindly to make that statement made to me a moment ago.

Mr. FULLERTON (Minnesota). A misunderstanding has arisen in regard to the open season of whitefish, that we had the discussion on yesterday. I have talked with several gentlemen who did not understand the position that we took in regard to letting the fishermen fish in the closed season.

We did not for a moment contemplate letting any fishermen fish in the open season, except it be under the jurisdiction and under the control of the state or federal authorities, both of Canada and of the United States. I hope this explanation will clear away a misunderstanding that existed, that the fishermen are allowed to go to the spawning beds and fish at will. That is not at all intended; that would not be tolerated for a moment. They must do their fishing and taking of the eggs only under the control of the authorities.

The PRESIDENT. The chair requests, then, that those who are here will explain to any members who are interested in this problem that this explanation has been made, because I can see how it is perfectly clear to those who are connected with our national hatcheries in the United States. It is so clear, indeed, that they did not emphasize it in the discussion yesterday afternoon.

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